EVALUATION OF ROLE OF JESS IN TRAUMA AND DEFORMITIES OF HAND AND FOOT

Thesis

For

Master of Surgery

(ORTHOPAEDICS)

M.L.B MEDICAL COLLEGE

BUNDELKHAND UNIVERSITY
JHANSI

2004 **PUNEET AGARWAL**

Dedicated
to my Mother
who was, is and will be
always with me to love
teach & guide

DEPARTMENT OF ORTHOPAEDIC SURGERY
Maharani Laxmi Bai Medical College
Bundelkhand University, Jhansi

Certificate

This is to certify that the present work entitled "EVALUATION OF ROLE OF JESS IN TRAUMA AND DEFORMITIES OF HAND AND FOOT" *has been carried out by the candidate* *Puneet Agrawal*, *himself under my direct supervision and guidance, in the department of Orthopaedics, MLB Medical College, Jhansi. The techniques and methods described were undertaking by the candidate himself and observations have been periodically checked by me.*

It is further certified that the candidate has also fulfilled all the pre-requisites necessary for the submission of this thesis.

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Date : 15-09-2003

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ACKNOWLEDGEMENT

I can not express my sense of great fullness on the words, for my revered teacher, Prof. R.P. Tripathi MS (Ortho), MAGS, Department of Orthopaedics, who lit the lamp of knowledge in my mind and soul. Whose blessings masterly guidance, constant encouragement, fatherly love, and valuable criticism encourage me in completing this work. He made me understand what exactly a pupil can learn form passionate teacher.

I am deeply obliged to Prof. P.K. Dabral, MS (Ortho), Prof & Head, Department of Othopaedics, who helped me to clear my confusions at several stages. I did derive benefit, pleasure and profit from their stimulating exchange of ideas, which I very humbly and deeply acknowledge.

I am also very grateful to Dr. D.K. Gupta MS (Ortho), Asso.Professor, Department of Orthopaedics, for his encouragement and valuable help.

I can not repay the debt to my parents for inculcating to proper habits and character. Whose blessing have always with me and been source of inspiration.

I am deeply indebted to the patients for their untiring cooperation, in-spite of their sufferings and economical restrains.

The tiresome work of proofreading has been ably assisted by Dr. Piyush Tripathi, Dr. Aashutosh and Dr. Dheeraj whose, help I can not forget.

I reserve my special thanks to my seniors, batch-mates and juniors for their unstinted support and cooperation.

Finally, I sincerely acknowledge the help of Mr. Vinod Raikwar (VK Graphics), who have taken unusual pains to get this work printed in its present form.

Place : Jhansi

Date : 15-09-2003

PUNEET AGRAWAL

CONTENTS

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INTRODUCTION

INRODUCTION

The Human body is an amalgamation of many fundamental units put together. Among these units, Hands and Feet have got a very distinct and important role. However the functions of these can't be over emphasized.

The Hand is capable of the strongest grasp, pinch and the most delicate touch. Its rich and complex sensory innervation allows the finest judgement of texture, volume and temperature. The value of a strong and well co-ordinate hand in activities such as writing, painting and manipulating tools is obvious. But perhaps less obvious is the extent to which the Hand is a reflection of personality and a vital organ of expression. One has only consider the manual signs and attitudes of an oriental dancer, the benedictions of a priest, the gesture of a conductor or a gallic raconteur, to realize how much more is the Hand than a prehensile and sensory tool. Injuries, diseases or surgical interferences therefore do much more than interfere with grip or touch, it expresses the personality itself. In disabilities of the Hands more than in any other region of the body, the finest surgery and after care are essential. Careless or in experienced surgery, insufficient or non-existent rehabilitation are alike inexcusable. Only those who have not worked with patients whose hands are seriously disabled, do not

realize how deep the disaster may penetrate and how much psychological trauma, often not manifest, can be caused.

All types of diseases affect the Hands, Infection, Arthritides, Neoplasms and Degeneration. But unfortunately, the Hand is also a subject to injury to an alarming degree.

It may not be widely appreciated how much can be done for the seriously disabled hand by intensive and long continued conservative treatment and to what extent rehabilitation can reinforce the dexterity and injurity of surgery.

During the last 15 years we have had an opportunity of studying and attempting to device correct techniques of rehabilitation in a variety of hand disorders. We have come to the firm conclusion that only by intensive, if necessary full time treatment, with the utmost attention to detail and careful and realistic planning for future occupation the best result can be obtained.

The treatment of hand injuries/ deformities involves development of muscle power, increase in joint range and redevelopment of coordination.

Over the centuries the Foot has undergone many changes which one can likes to the stages in the development of automobiles. In both instances, each improvement in the original crude model has resulted

in a progressive advancement in locomotion at the same time. Because the form and function of the Foot normally contributes to a major degree to body locomotion as a whole it is essential that the Foot be regarded in relation to the entire body rather than considered as a separate event.

To talk about the deformities of the Foot, from the prognostic viewpoint, the most important are, probably, the patients with club foot.

The significance of clubfoot is manifold-

- It is a common deformity. The incidence being 1 in every 1000 birth.
- It is easily diagnosed at the time of birth.
- It is amenable to treat at various stages.
- If neglected, it would leads to severe deformities, both functional and cosmetic.

The aim of treatment is to obtain a planti-grade, pliable and cosmetically acceptable foot in shortest possible time. Whole of the specialized weight bearing skin of sole should be used while walking, joints of ankle and foot having normal mobility and after treatment the affected foot should match its normal counterpart as close as

possible. Feet should be in normal shape as much possible, so as to fit snugly into the shoes without any unwanted pressure points.

After considering all factors, external stabilization system offers the best solution in unstable and compound injuries and correcting other deformities. With the use of thin smooth wires, which are placed, away from the injury site in a stable configuration, **JOSHI'S EXTERNAL STABILIZING SYSTEM, (JESS), provides a stable skeletal environment** aiding rapid healing of soft tissue with establishment of microvascular circulation, immediate active and passive mobilization of the uninjured adjacent joints. This restores microcirculation and prevents lymphovenous stasis leading to lesser incidence of infections. It allows management and care of soft tissue injuries without disturbing the fracture site in compound injuries, which is not possible by using other methods.

JESS also permits the compression-distraction and lengthening. It is a cheap and easily available minifixator (as compare to Hoffman's fixator) which has all the advantages of the other fixator.

- The system is simple and modular.
- It assists the surgeon in obtaining tissue stabilization, spontaneous revascularization and tissue expansion by gradual and controlled distraction.

- Precise positioning of the Hand allows tissue transfer, tissue transplant or other reconstructions with simultaneous correction of malalignment and joint mobilization.

The principle of controlled differential fractional distraction is applied to correct all deformities by gradual sequential stretching of soft tissues through K-wires anchored in bone. This provides a continuous sustained stress on the tissues and causes cellular hyperplasia for tissues histiogenesis. Any procedure, which could confirm to mechanism of correction by direct placement of pin and distracting device over the base of deformity to straighten, the apex would probably be the most rational method. According to the principle of differential distraction, the concavity opens out, the convexity needs to be realigned to prevent compression and both concave and convex sides of the deformity are distracted. The convex side distraction is half the rate of the concave side. JESS distraction device fulfills all the criteria to correct the deformity. It directs the tissues towards final correction with care control and without crushing. Advantages of Joshi's external stabilization system are as follows:-

≡ Lengthening of all contracted tissues thus promoting histiogenesis.

- ≡ To control the magnitudes of correction of various components of deformity depending on the severity in a given case.
- ≡ Avoids cutting of tissues and resultant scarring.
- ≡ Resultant foot is supple than the ones treated by surgical method.

AIMS
&
OBJECTIVES

AIMS AND OBJECTIVES

1] *Evaluation of Dr. Joshi's fixator in management of various deformities of the hands and feet such as complex fracture. Congenital deformities, late presenting neglected hands and feet problems, post burn contracture etc.*

2] *Evaluation of Dr. Joshi's fixator in facilitation of soft tissue coverage by flaps and graft in compound mutilating hands injuries.*

REVIEW OF LITERATURE

REVIEW OF LITERATURE

As we know human beings carry out their profession and daily activities with the help of then efficient tools of nature i.e. Hands and Feet, even by having minute disturbances in then he is liable to suffer not only economically but also emotionally & socially.

DEFORMITIES/TRAUMA OF HAND

Fractures of the hand are the most frequent of all fractures. These fractures frequently involve more than one bone of hand and have intra-articular extensions, may be associated with dislocation and usually involve the soft tissue extensively. In most of these cases, conservative treatment with plaster leads to malunited fractures, unreduced dislocation and poor soft tissue care. Intramedullary fixation may lead to rotational instability, telescopy and poor fixation. External fixator at the same time achieves and maintain accurate alignment, permits soft tissue care, spares the proximal joints and cause least periosteal stripping. At present external fixation is a universally accepted technique for the treatment of fractures or dislocations of hand for prevention of subsequent deformities.

Management of long bone fractures by external fixation is in regular clinical practice since 1960's, But the concept of external

fixation in small bones gain popularity in 1980's. Literature is scarce regarding its use in the treatment for hands and forearm injuries.

Earlier methods of external fixation in hand injuries included pin anchored in acrylic frame and small Roger Anderson metallic Frame. These methods were simple to apply but did not have stability and modularity. *Henry Jacquet (1976* was the 1st person who developed fixation with a mini-external fixator for skeletal and soft tissue support in severe hand injuries.

Henry Lambotte popularized it in Britain in 1903. However due to complications related to the pin track infection at the site of insertion, the technique lost its popularity. The earlier instruments did not permit rotational and axial alignment.

Codivilla (1905) and *Putti (1918)* combined pins and plaster for leg lengthening. The introduction by the 1930's of transfixion pins, longitudinal distraction and compression mechanism and universal articulations led to very sophisticated devices of *Anderson (1936) Stader (1937)* and *Hoffmann (1954)*.

Dr. Hoffmann in 1954 first produced pins with threads to achieve better purchase ion bone. He also developed clamps that were adjustable, helping to correct rotation and angulation.

After world war II *Ilizarov(1972)* developed highly complex, but versatile ring fixator which appeared to be well suited to the correction of limb length discrepancies, mal alignments and segmental transport after corticotomy.

Disksons & Crockitt DJ (1975) suggested that if the ulnar three metacarpals are all fractured, rigidity of fixation can be achieved by leaving the K-wire protruding the skin and bending them with methyl metha-acrylate and a longitudinal interconnecting K-wire strut.

Rosenburg L and *Kon M (1986)* and *Scott M (1980)* and *Mulligan PJ* use home made fixator with cement and rigid plastic tube for finger reconstruction and severe phalangeal fractures.

Stuchin & Kummir's (1984) laboratory comparison of various method showed that the commercial system has a clearly superior pin but greater rigidity was achieved with certain configuration of reinforced bone cement.

Howard FM (1987) used combination of tension band wiring and an external fixator for Rolando fracture. The external fixator is used to align the comminuted fragments and to restore length and tension & band wiring provide stability.

Milkford (1987) suggested mini external fixator for open or severely comminuted fractures of the phalanges.

Scharf W, Hurtz W, Wagner M (1984) suggested that mini external fixator in the treatment of multiple fragment fractures of the base of radius and of the forearm. The external fixation can also be used with good success. The external mini fixator is a new way for external stabilization in the hand surgery and can provide good results in comminuted fractures of the fingers and for finger replantation.

Schuned F, Donker Woleke M, Burney F (1984) used mini external fixator in the treatment of 63 closed diaphyseal-metaphyseal fractures. A simple half frame configuration was applied in the all cases and open reduction was performed in 26% cases the mean duration of external fixation was 30 days. There was no case of non-union and anatomical reduction was obtained in 86% of cases. There was no case of reflex sympathetic dystrophy. The general functional results were very good or good in 96% and open reduction did not significantly alter the final results. They inferred, that for treatment of metacarpal fractures closed reduction or open reduction with stabilization by an external fixator is a useful alternative.

Dr. Brij Bhushan Joshi of Bombay (1988) develop a simple light mini external fixator system for use in fracture in hand. It came to be known as JESS (Joshi external stabilization system). Dr. Joshi used this system in more than 150 cases of crush injury of hand involving soft tissues and bone in varying degree of severity. He

found that this assembly to be very effective in stabilizing the skeleton in functional position to allow soft tissue assessment and subsequently soft tissue healing. This system is simple and modular. This system provides tissue stabilization, spontaneous revascularization and tissue expansion by gradual and controlled distraction. Precise position of hand allows tissue transfer, tissue transplants or other reconstructions with simultaneous correction of mal alignment with joint mobilization.

Solinas S, Affani M (1989) described a new method for external fixation of phalangeal fractures. This method is not traumatic and very easy to perform. It permitted early mobilization and good healing in a series of 20 patients.

Cziffer E (1989) designed a disposable mini external fixator, suitable for either provisional or definitive fixation of hand or foot fracture. The system is simple disposable, relatively radiolucent & inexpensive. It has been listed in a human laboratory and has been used successfully in 27 cases.

Buchler et al (1991) described techniques for Rolando fractures that combine external fixation with limited internal fixation and bone grafting. He showed that in 20 displaced comminuted fractures of thumb CMC joint which were treated by external fixation, 75% of

patients have very good results after follow up for 3 years. As compared with uninvolved side,the patient achieves axial rotational average 79% radial adduction 89%, Key pinch 88%, Grip strength 81%.

Eyres and co-workers (1993) used Charnley compression clamp attached to transverse 2.0mm K-wires for treating various combinations of metacarpal fractures.

Sameer I, Shehadi (1991) used mini external fixator in difficult hand injuries after closed reduction and external fixation. In this study they exclude patients with fractures of distal phalanx, undisplaced and stable fractures and those displaced fractures, where a stable closed reduction could be achieved. The K-wire was introduced transversely at a 90° to the long axis of bone, one at the mid lateral angle and the second about 2.0mm dorsal to the first. The K-wires are then fixed externally with methyl metha-acrylate rods, made by introducing the methyl metha-acrylate, while still soft, inside clear plastic tubes slit open on the side. The open side of the tube was then applied against the free ends of the K-wires and allowed to set in 5-10 min, thus stabilizing the fracture. They utilized the plastic tubes for packing K-wires or the softener suction tubing for this purpose. Percentage return of total range of motion in phalangeal fracture varied from 66%

to 98% (mean 84%) and in metacarpal fracture it varied from 77 to 100% (mean 96%).

Ashmead, D roth et al (1992) used external fixation not only for the skeletal stabilization but also for the management of soft tissue in 29 cases of acute hand injuries.

Parson SW, Fit Zerald ja shearer (1992) treated complex metacarpal and phalangeal fracture by Shearer micro external fixator. This fixator consists of unpolished stainless steel rods, which may be used singly or linked by an articulating central block. The fracture may be first reduced and then fixed externally or the fixator can be applied with two rods and central block, thus allowing early joint mobilization with good or excellent function.

Stark RH (1993) used mini external fixator in treatment of difficult PIP joint fractures. This article presents an alternative method consisting of close treatment of complex PIP joint fractures with a mini external fixator. The method utilizes the traction principle without necessitating a complex outrigger system. Immobilization is reduced to 3 weeks and cases presented with excellent clinical result despite sub optimal roentgenographic appearance.

Schneider P (1993) used a simple external fixator of K-wire and electric clips for use on fingers.

Nagi L (1993) use static external fixation of finger fracture besides its common indication in massive, high-energy trauma and contaminated fractures. It offers true alternative to ORIF and represents a superior treatment modality in selected cases of extensive comminution.

Schmidt I et al (1995) a specific joint bridging construction make it possible to treat severe joint fractures by ligamentotaxis. Another indication is the preoperative continuous elongation treatment in severe contractures of finger. It can be made dynamic and can also be used for inter fragmental compression and distraction.

Penning et al (1995) used a mini fixator system to assist the operative correction of soft tissue contractures. The external fixator served as a tool for gradual correction and to severe joint positions after soft tissue release. Following wound healing certain fixator components were unlocked and joint mobilization initiated. The functional results in sustained grip strength reached to by 82% compared to the uninjured opposite site.

Friker R et al (1996) showed that fracture of the hand and finger showing comminution or associated soft tissue lesions are best treated with external fixation. In contrast to other system, the new AO mini external fixator enables less bulky unilateral fixation facilitating early

mobilization and the special design of the double clamp allow preliminary intra operative stabilization with only one wire in each fragment. Out of 20 patients in their study no one developed nonunion.

Drenth DJ, Klasen HJ (1998) from 1982 to 1993 treated 33 patients with 29 phalengeal and 7 metacarpal fractures by external fixation using a mini Hoffman's device. The functional results after metacarpal fractures were better than those after phalangeal fractures and fractures of the middle phalanx had better recovery than those of the proximal phalanx. 28 of the 33 patients were satisfied with their results.

McCulley SJ, Hasting C (1999) presented an alternative cheap method of external fixations comprising of the disposable sheath of an IV cannula as the cross bar, held by K-wires as the pins. This has been used in gunshot wound with highly comminuted fracture. The method is inexpensive, simple to use and quick to apply. Good bone length and union is achieved and stability was excellent, allowing early motion. They recommended this method when no standard fixator sets are available to surgeon.

Salafia A, Chauhan G (1997) used JESS for the correction of proximal IP joint deformity of hand in 68 finger cases of leprosy

patient's. They achieved full extension in 75% of cases and good extension in 10% of the cases.

DEFORMITIES / TRAUMA OF FOOT

The human foot has become greatly specialized for performance of two divergent functions. Both of these functions are dynamic: -

1.) In standing it must provide a stable support for body weight-balance (a passive function).

2.) In walking it must, in addition to supporting the body weight, provide a resilient spring or lever by which the body weight can be propelled forward- propulsion an active function.

These objectives are fulfilled by the architectural arrangement of a number of small spongy elastic bones grouped together in the form of series of arches. For each of the function muscle contractions are essential thus importance being greater in propulsion than in balancing.

Most of the knowledge of medicine and surgery, practiced in old time is derived from Egypt. The earliest documentation of foot disorder comes in form of wall painting and preserved writing on mummies. Paintings on the walls of the ancient tombs depict child with a clubfoot deformity and a statue of diastrophic dwarf with a clubfoot can be found in the *Tutan-Khamen* collection.

Hallus valgus consists of abnormal adduction of the proximal phalanx of the great toe towards the mid line of the foot and is associated, especially in most extreme form with varying degree of varus of the 1st metacarpal. *Lapidus (1934)* suggested the form "Metatarsus versus primus" to indicate a primary developmental type of entity. *Lake (1942)* considered varus deviation of the metatarsal as the most important factor. *Kaplan (1951)* described a strong contraction band extending from the tendon of tibials posterior muscle into the flexor hallucis brevis and adductor hallucis and regarded this a contributing factor. Conservative treatment consists of properly well fitting shoe. Operative treatment consists of McBride operation, Mitchell metatarsal osteotomy (1958), Keller arthroplasty, and Ross Smith arthrodesis of MP joint.

Pes Cavus or the claw foot consists of clawing of the toes combined with a raising long arch of foot. *Jones and Lovett* reported cause of claw foot due to polio and inflammatory infections. Ducchenne originally suggested that it was due to the weakness of the short muscles of the big toe and interossii. *Werton et al (1962)* in a review of 629 cases of claw foot found that 25% of them had some degree of neurological involvement. *Scarpyener (1945)* reported congenital stricture of spinal canal. *Giannestas (1953)* reported right equinocavovarus foot due to intrathecal traction. Treatment includes

both conservative and operative. Conservative treatment allows the re-education of the small muscles functions by intrinsic exercise. Operative treatment include Lambrinudi operation (1927), Girdle stone tendon transfer operation (Taylor 1951), Japasmid Tarsal V osteotomy with steindler's stripping of plantar fascia.

CLUB FOOT

"Club foot", "Piede torto", "Piebot", "PieZambo", "Klumpfuss" are worldwide synonyms for Talipes equinovarus a congenital deformity that has continued to plague the medical profession before the days of *Hippocrates*.

Archeological investigators in Mexico revealed that the Aztecs recognised clubfoot, treating it with splints made of cactus leaves.

Hippocrates first described clubfoot deformity around 300BC. He emphasized early and gentle treatment for the anomaly. The treatment consists of "Moulding of foot with piece of wax, applying resinous cerates with numerous bandages. In this process one should bring the parts into their natural position, both that are twisted and those, that are abnormally contracted, adjusting them in this way by hands and by bandaging in a manner so as to draw them into position gently and not violently" (*translation by Withington, 1927)*.

A club foot deformity may also be acquired after birth secondary to muscle imbalance as in cerebral palsy, muscular dystrophy or poliomyelitis. Examples of this is seen in the famous painting by *spanish artist Ribera (1588-1656),* "Pie-Bot" which is hanging in the Louvre museum, the subject is a boy with a right sided hemiplegia with talipes equinovarus deformity obviously a victim of cerebral palsy.

In the middle of 17^{th} century, *Arcaeus, Pares and Fabrig* recommended, repeated stretching by the use of mechanical corrective apparatus, which gradually eliminated the deformity with a turn-buckle.

Scarpa in 1803 described the pathologic anatomy in "A Memoir, on the congenital talipus equinovarus in Children". In this treatise he described the deformity as a "twisting of the scaphoid, Os Calcis & Cuboid around Astragalus", calling it a "Congenital dislocation of the astragalocalcanioscaphoid complex". *Scarpa* also described the contractures of the soft parts and devised an apparatus with springs in an attempt to stretch the contractures and reduce the scaphoid.

Subcutaneous tenotomy of the achilles tendon was first performed by *Lorenz, in Frankfort, in 1782.*

Geurin in 1838 appears to have been the first to report the use of plaster of paris in treatment of clubfoot.

Little published a paper 'A treatise on nature of clubfoot' in 1839. He was Englishman and had on attack of polio at the age 4 year and his left leg was paralyzed which later resulted into talipes equinovarus deformity. He went to Germany in 1835 having read the work of Stromeyer. He also went to Honover, where *Stromeyer* performed subcutaneous tenotomy and corrected his deformity. During his convalescence, Stromeyer taught him how to perform this operation. Later on Little worked on clubfoot in Germany and presented a thesis for which he was awarded Doctor in Medicine in Berlin. Later on he devoted all his life to the care of crippled. He also noticed a case of pseudo muscular atrophy and presented a paper before obstetrical society of London, entitled on influence of abnormal parturition, difficult labor, premature birth and asphyxia neonatorum, on the mental and physical condition of child especially in relation to deformity. Later on above condition with cerebral palsy was called "Little's disease".

In *1857, Solly* performed first bony operation for clubfoot, in which he removed a part of the cuboid, which was a precursor of the present day Dillwynn-Evans operation.

In 1860, Adams differentiated the acquired talipes equinovarus from the congenital variety. He also noted that head and neck of the talus were deviated medially. He felt this was a second-degree adaptive change.

Lund performed the 1st recorded talectomy for clubfoot in 1872.

In 1890 Phelps, in NewYork City, described a one staged medial plantar soft tissue release with lengthening of the tendons. He also performed an osteotomy of the neck of talus with wedge resection of calcaneum.

In 1898, Walshingham & Hughes renewed interest in theory that the deformity was due to a germ plasm defect of the head of talus. They reported osteotomy of talus as a means of correction.

In 1906 Codvilla from Itally described a soft tissue release with lengthening of tendons, including the anterior tibial. He advocated soft-tissue surgery should be done when a child is about 3 years of age.

In 1930, Kite popularized non-operative treatment with serial manipulation and plaster cast immobilization.

In 1934 Denis-Browne renewed interest in mechanical intrauterine pressure as cause of the deformity. He advised forceful

manipulation before application of his splint which fallen into disrepute because it caused deformity of bones and stiffness of joints.

Leo Mayer (1934) assessed that Equinus position of OS calcis is extremely difficult to correct, for which he devised a method which consisted of inserting of a nail or wire through posterior portion of OS-calcis by means of which, following tenotomy and posterior capsulotomy, the posterior portion of OS-calcis can be pulled downward and anterior portion upwards. A six weeks period of immobilization was employed.

Shin Movita & Kyoto in 1962 devised a method for treatment of resistant clubfoot deformities in children up to 6 years of age. After heel cord lengthening, occasionally combined with posterior capsulotomy, leverage wire traction is applied directly to calcaneus by means of K-wire and padded foot plate, both of which are incorporated in plaster cast between manipulation. After correction of eqinus and varus deformity of heel, the wire is removed and subsequent correction is completed by manipulation and plaster casts.

Prof. Gavrill Abramovich devised an external fixator in 1951 in Russia. He advocated the use of ring fixator in correction of the deformity in CTEV. By applying the fixator, not only the bone but

also the muscles, nerves, blood vessels and tissue grow simultaneously.

Grill & Franke (1987) noticed importance of the discrepancy in length between the medial and lateral border of foot in correction of the deformity and achieved continous distraction by external fixator.

Cantine et al (1990) presented management of relapsed clubfoot and other severe foot deformities with the Ilizarov external fixator. He reused it on 14 feet in 13 children aged 2-16 years. It included 8 idiopathic relapsed clubfoot and 6 severely deformed feet secondary to teratogenic or neurological anomalies. Plantigrade and functional foot was obtained in all of idiopathic clubfeet and in 2 of the teratogenic deformed foot.

At the present scenario, JESS has been develop by, Dr B B Joshi in Mumbai, India in 1988. Today it has evolved into a sophisticated system with applications in trauma, defects and deformities in the upper and lower extremities. It has a special application in the correction of clubfoot resistant to conservative management. The principle of fractional distraction as popularized by Ilizarov in 1980, is the basis of correction of deformity. Dr. Joshi added the concept of differential distraction to this basic principle. In differential distraction the concave side of the deformity is distracted

at twice the rate of the tissues on the convex side, lengthen the limb and effectively corrects the deformity at the same time. He presented this technique at the first international conference on clubfoot at Milwaukee (USA) in 1990. This method is an extension of conservative method with osseous holds. Since only soft tissue stretching is involved, the corrected foot is supple than the operated cases. Over correction is usually not seen except for the cases, which Turco calls atypical TEV. This is avoidable by weekly inspection, we can stop distraction at that stage if it does occurs, it can be reversed by prolonged immobilization to allow the tissues to fall back, as any tissue which can be stretched has got the capacity to shrink in proper environment. It has a shorter learning curve than an open surgical procedure, which require more skills to get full correction and demands cutting of many tissues to secure bony alignment. JESS frame is designed to provide simultaneous three-dimensional correction of this deformity. It has been widely used in resistant, recurrent and neglected deformity with success. Dr. Joshi has made India proud. Awards and recognition for his work are numerous. Amongst his most recent are the Indian council of Medical Research Award (1986) and *"A best Citizen of India Award" in 1998.*

MATERIAL
&
METHODS

MATERIAL AND METHODS

The present study shall comprise the "Evaluation of role of Joshi's external stabilizing system in hand and foot deformities and injuries" in the Department of Orthopaedics, MLB Medical College, Jhansi, during the year 2002-2003.

The study was conducted on 40 patients of hand injuries including both sexes (M=36, F=4). In this study we include patients of all kinds of hand injuries i.e. closed and open. All types of JESS frame have been applied as per pattern of injury in individual patients.

All the cases assessed clinically and radiologically before and after operations, along with subsequent follow up. All the necessary and useful procedures have been done to improve the functions of hand considering the cosmetic aspect.

HAND INJURIES

Criteria for selection of patient

Patients of all age groups, both male and female with open and closed fractures of hand and forearm were included in this series.

Preoperative assessment

1. History (Time, place and mode of injury) & General examination
2. General routine investigation
3. Pre-operative X-ray of local part at least in two views- Antero-posterior, Lateral/oblique view.

Classification of bony injuries

A. (1) Simple (2) Compound

B. (1) Non-comminuted (2) Comminuted

C. (1) Intra-articular (2) Extra-articular

Principles of Management :

1. Stable reduction, anatomical when possible.
2. Maintenance of length and rotation of digit.
3. Appropriate care of associated soft tissue injuries.
4. Mobilization of uninvolved digits and adjacent joints
5. Prevention of lympho venous stasis.

6. Ability to add dynamic component into the frame and permit concurrent mobility of the joints of the injured limb.

PROTOCOL OF MANAGEMENT

1. Preliminary evaluation and simple lavage : The injury is evaluated in terms of tissue damage and a gentle wash is given and the limb covered with sterile dressings till the patient can be taken up for surgery. In the mean time, the hand is supported with a T-splint/POP slab.

2. Before the external fixator procedure to be done, the operative and post-operative complications and the likely results were explained to all the patients and consent was taken.

3. The patient is anaesthetized (mostly regional anesthesia with or without sedation) and a tourniquet applied to the limb though not inflated. It is used only if excessive bleeding is noticed, to reduce the losses. The limb is thoroughly cleaned with cetavalon/ mild soap solution and copious amount of saline. The part is painted with povidone iodine and drapped.

4. Following painting and draping, the standard frame is applied to the limb, so as to maintain the functional position. Flexion of MP joints (60°), flexion of IP joint (10-15°) and abduction and apposition of the thumb ray.

5. While applying the fixator due attention is given to the reduction and stabilization of the individual fractures. Though it is desirable to obtain accurate reduction of all the fractures, it is not mandatory as long as the position of hand is acceptable.

6. A second wash is given after the application of fixator. As the limb becomes stable, it is easy to inspect and identified individual tendons and devitalized parts of the skin and other soft tissues along with foreign bodies and free bone pieces are removed. The real debridement and decontamination is thus performed only after applying the fixator.

7. Antibiotic therapy, tetanus and gas gangrene prophylaxis is instituted as per indications.

8. Dressing and subsequent wound management is done on the conventional lines.

9. Mobility is instituted early, once it is clinically apparent that the fractures have sufficiently healed. The same frame can be modified to facilitate assisted mobilization and subsequently for active mobilization. The minor changes for above objective involve-replacement of original nylon or silk threads holding the fingers by rubber bands which can

alternately attached to the frame in position of flexion and extension of IP joints and the MP joints. The hinges suitably placed at the level of joints can be made loose for the same purpose.

10. Secondary procedure for skin coverage, bone grafting, tendon surgery are performed with the limb stabilized on the fixator itself.

11. Once the wounds have healed and the basic skeletal support has stabilized, it is desirable to take out the frame and provide dynamic splints. The ultimate results can be improved upon by various reconstructive procedures.

BASIC COMPONENTS OF *JESS*

A) ***LINK JOINTS:*** - Link joints are the heart of the JESS. These simple, lightweight and versatile basic joints are capable of firmly gripping a Kirshner wire and a connecting rod at right angle to each other. A recessed third hexagonal nut in the third axis, which is perpendicular to the two holes, allows an intra osseous K-wire and an external connecting rod to be clamped severely in two different axes. Link joints are available in three sizes for application in various situations-

i) *Mini link joints (Alpha clamp)* – accommodates 2.0mm connecting rod and up to 2mm K-wire.

ii) *Medium link joints (Beta clamp)* – accommodate 3-4 mm connecting rod with up to 3mm K-wire.

iii) *Large link joints* – accommodate a rod and a wire of a combined diameter up to 8mm.

iv) *Modified link joints-*

(a) oval or oblong hole

(b) open mouth link joints

(c) independent control joint

(d) Sliding link joint.

B) ***CONNECTING RODS*** **:** Various lengths of smooth and angled rods are used in 3mm and 4mm diameter.

C) ***KIRSHNER WIRES*** – 1.2mm, 1.5mm and 2.0mm K-wires with trocar ends in 15cm and 20cm length are used. 1.5mm K-wires are used in phalanges, 1.5-2mm in metacarpals and 2mm for larger bones of the forearm.

D) ***DISTRACTION AND COMPRESSION EXTERNAL FIXATORS*** – This is the most important component for correction of deformities, lengthening procedures and in situations where

compression/distraction is needed. Each fixator consists of a threaded rod with one static block and one translating block. Each block may have one or two holes for holding one or two wires. A 360° revolution of the square knob at the end of the threaded rod produces translation equal to the pitch of the threaded rod in the longitudinal axis. This equals to 0.8mm in 4mmm distractor and 1mm in 6mm distractor.

Various D/C external fixators are –

1. *Standard D/C external fixator* – This has threaded rod of 4mm diameter with 0.8mm pitch of the thread. K-wire block has 1 or 2 holes with length of threaded rods are 10cm and 15cm.
2. *Small D/C external fixator* – This has threaded rod of 7.5cm long with single hole block for K-wire.
3. *Large D/C external fixator* – This has a threaded rod of 6mm diameter with double hole block for K-wires.
4. *Extra long D/C external fixator*
5. *Swivel D/C external fixator* – The K-wire holding block can swivel and translate simultaneously with revolution of square knob.
6. *Open mouth D/C unit*

7. *Turn-Buckle type of D/C external fixator* – The external fixator has two partially threaded 4mm rods housed in a central sleeve which when rotated causes distraction or compression of both the limbs. Thus one turn of the sleeve through 360° causes a distraction or compression of 2mm.

E) ***HINGS*** - These components are require for correction of deformities, mobilization of joints and positioning of the frames at a desired angle.

Three types of hinges used are-

i) Uniaxial uniplaner hings

ii) Biaxial uniplaner hings

iii) Biaxial biplaner hings

F) ***THREADED SLEEVES AND NUTS***

INSTRUMENTATION

Instruments for the applications and maintenance of JESS are simple.

- Hand drill (Electrical, pneumatic or mechanical)
- T-Handle with chuck
- A pair of pliers
- Wire-cutters
- Spanner no. 6,7,8 & 9

- Allen keys 2.5mm and 3mm
- Rod benders.

JESS frames are constructed on K-wire passed through safe corridors in different parts of the hand.

JESS FRAME CONSTRUCTION

BASIC FRAME :

Basic frame are designed for positioning of the wrist, hand and fingers in the treatment of acute traumatic and in post operative conditions of the hand. A thorough understanding of biomechanics and frame configuration is essential for using the system to its fullest potential.

There are certain peculiarities that makes the hand and forearm unique from the other long bones and these need to be considered, while using any immobilizer for the hand and forearm. They are as follows-

1. Network of neurovascular bundles.
2. Complex anatomical relationships between soft tissue
3. Large number of individually mobile segments intricately balanced by soft tissues.
4. Short bone segments offering even smaller safe zones for fixation.

5. Angulatory and torsional forces acting on hand even at rest
6. Negligible axial loading
7. Complex skeletal architecture including multiple arches.
8. Complex movements like supination- pronation of the forearm.
9. Propensity for stiffening in non-functional attitudes.

In the injured hand, many of these factors assume insurmountable proportions and require a highly modular and versatile system capable of delivering uniformly satisfactory results, with intelligent modifications in configurations.

The commonly useful assemblies are –

1) THE 'U' FRAME -

Indication - For distal phalanx.

Frame construction – One K-wire is passed transversely in the base of distal phalanx and a longitudinal wire is passed through the length of the phalanx. These wires are connected by a "U" frame connecting rod in the frontal plane.

2) "L" FRAME

Indication : For stabilization in factures of distal phalanx; As traction bow for distal phalangeal traction in other frames.

Frame construction – One K-wire is passed antero-posteriorly at the base of distal phalanx, proximal to the nail bed and palmer end is bent. A small incision is made at the exit point on palmer aspect and the K-wire is pulled on the dorsal side. Another K-wire from the tip is introduced longitudinally up to the base of the distal phalanx.

3) UNILATERAL FRAME-

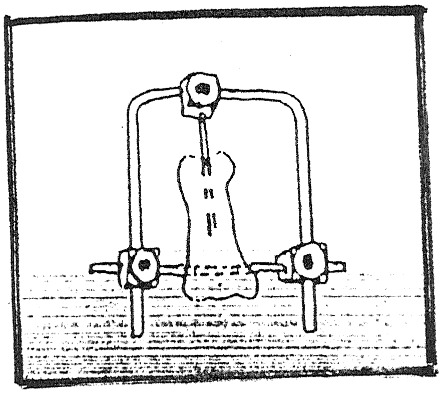
Indication – Isolated fracture of the index, little finger or thumb.

Frame construction – Two transverse K-wires are passed proximal and distal to fracture in each fragments and connected with a single connecting rod. A second rod, when required, should be placed a few mm laterals to the first rod in mirror image configuration.

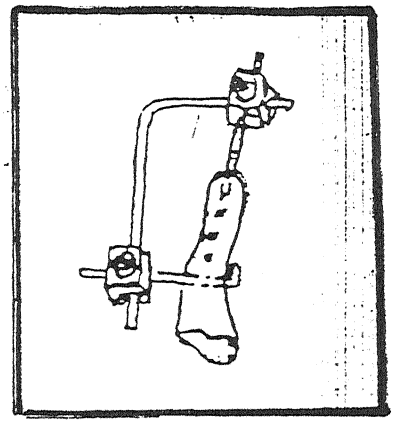
4) DORSOLATERAL FRAME-

Indication – for isolated phalangeal fractures in middle and ring fingers.

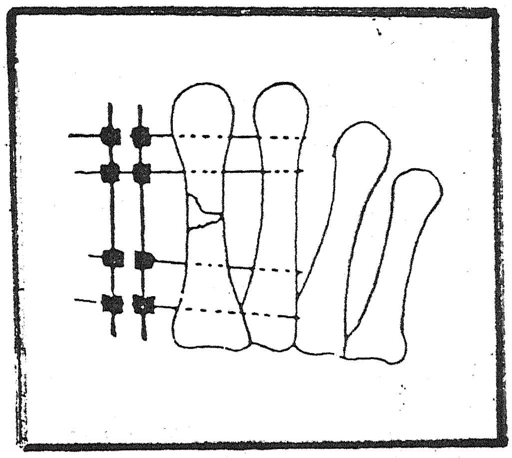
Frame construction – This frame is identical to the unilateral frame except that the K-wires are inserted in a plane of 45° to the transverse plane of the phalanges.



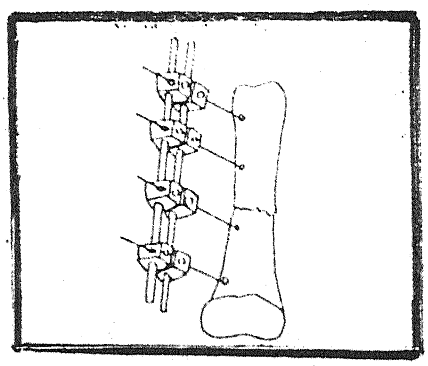
U- FRAME



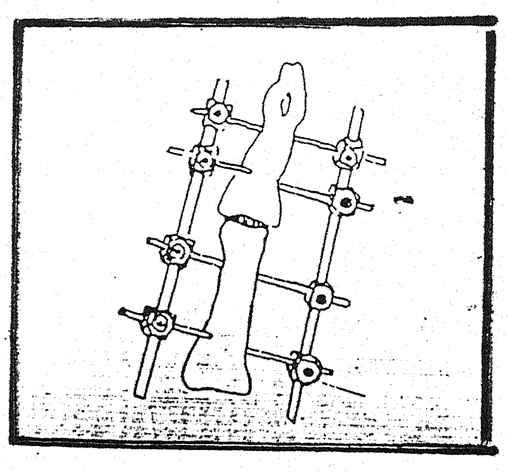
L-FRAME



UNILATERAL FRAME



DORSOLATERAL FRAME



BILATERAL FRAME

5) **BILATERAL FRAME** –

Indication – Used mainly for the articular or periarticular fractures as a joint spanning frame. Especially used for thumb fractures, even first metacarpal fractures.

Frame construction – Transverse transfixing wires are passed proximal and distal to the fracture site in the phalanx. These are connected by two parallel connecting rods, one on either side of the finger.

6) **DELTA FRAME (DOUBLE DORSOLATRAL FRAME)-**

Indications – used in comminuted diaphyseal fractures of the metacarpal and phalanx.

Frame construction – four dorsolaterally oriented wires are passed in the phalanx. The first wire is passed in the base on the radial side, the second in the base on the ulnar side of phalanx. The remaining two wires are passed in the neck, one on the radial and the other on ulnar side. The radial and ulnar wires are connected by two separate connecting rods. These two connecting rods are then linked to each other by a proximal and a distal connecting rod, completing a rectangular construct of connecting rods on the dorsal aspect of the proximal phalanx.

Variants – Transverse connecting bar may be curved for better function of the clamps.

7) ANGLED "J" FRAME -

Indication – For fractures of the proximal shaft or the head and neck of metacarpal or phalanx.

Frame construction – Two parallel k- wires are passed in the larger fragment of the metacarpal or phalanx as apart as possible on the outer aspect or dorsal obliquely. Pass a K-wire parallel to the previous k-wires in the same plane in the smaller fragment of the metacarpal or phalanx. An angled "j" shaped connecting rod is joined to the intra osseous k-wires by link joints to stabilize the fracture fragments. One link joint is mounted over the curved segment of the angled "j" shaped connecting rod & a K-wire is passed through it in a oblique direction making an obtuse angle with the previous k-wires. All the link joints are subsequently tightened. The straight part of the "J" frame is strengthened by additional connecting rod.

8) SYNDACTYLY FRAME:

Indication – For immobilization of fingers, after separation of simple & complex syndactyly, this facilitates grafting procedures, prevents maceration & permits easy & pain free change of dressings.

- Release of contractures of multiple fingers with skin grafting.

- Positioning in early burns or during post burns reconstructive surgery.

Frame construction -Two transverse and parallel k-wires are passed perpendicular to the shaft of second metacarpal from radial side & impale third metacarpal also. Two wires are then passed from the ulnar side, similarly to impale the fifth & forth metacarpals. One connecting rod is fixed on either side paralleling the border metacarpals & should extend at least 5-7mm beyond the fingertip. At their terminal end, these rods are connected to each other by a transverse connecting rod. Individual fingers are then anchored to the transverse rod of the frame by sutures in the nail or by longitudinal wires passed from the fingertip into the distal & middle phalanges.

VARIATIONS

Web–spacer frame: - After multiple web space reconstruction, the finger must be separated, but motion in the interphalangeal joints need not be restricted. For this, vertical K-wires are passed in the neck of proximal phalanges of all four fingers. Single, lateral, K-wires are passed in the index and little fingers at the same level as the vertical wires. An arched connecting rod bent at right angle at each end is attached to these wires. This gives a hold in two axes and thus prevents wire pull out in any individual axis.

9) RAY FRAME-

Indication – Multiple fractures in the same digit, positioning of a ray in reconstructive surgery of the ray.

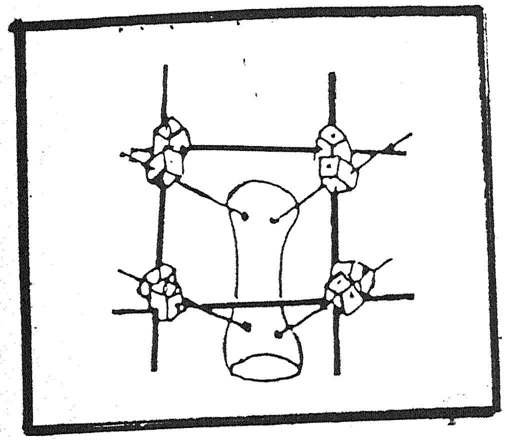
Frame construction – When applied to the index or the little finger it resembles a unilateral frame. The entire ray can be immobilized in any desired position. Two K-wires are passed transversely in the metacarpal for transfixion. One transverse wire is passed in each of the phalanges parallel and in plane of the phalanx. One connecting rod fixes the metacarpal K-wires. Another rod fixes the phalangeal K-wires. The two connecting rods are joined either by a hinge or the connecting bar at MP joints to the desired angle. The hinge allows fixation in the functional position.

10) POSITIONAL FRAME FOR THE HAND-

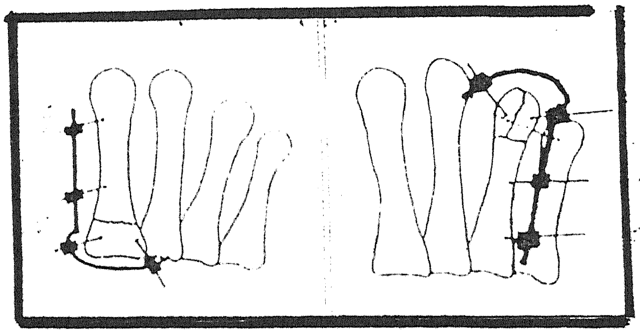
The description of this frame is simplified when the forearm, metacarpal and the fingers are considered as separate segments.

i) Forearm segment

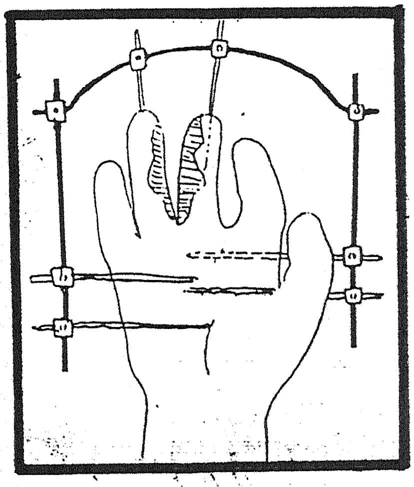
Radius fixation – One transverse wire is passed in the distal metaphyseal area of the radius. Another wire, parallel to the first is passed at the junction of the upper and middle third of the radius. A connecting rod is applied to these wires about a fingerbreadth away



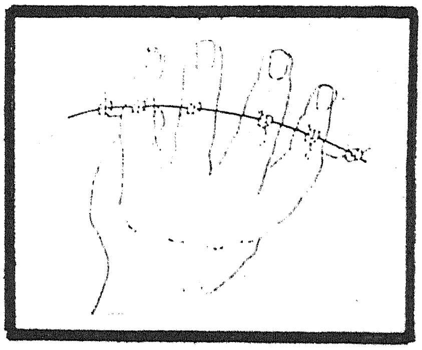
DELTA FRAME



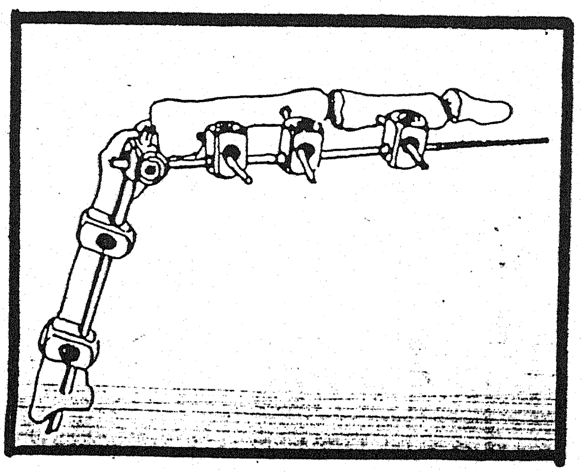
ANGLED "J" FRAME



SYNDACTYLY FRAME



WEB SPACER FRAME



RAY FRAME

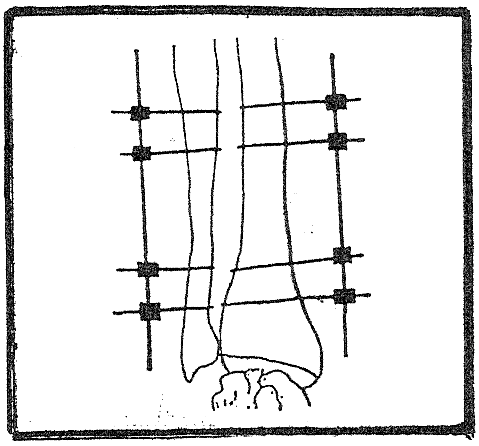
from the skin. The rod ends at the level of the wrist to allow attachment of a hinge at this level.

Fixation of the ulna – The ulna is fixed by two transverse wires similar to the radius. The wires are co-planer with radius wires.

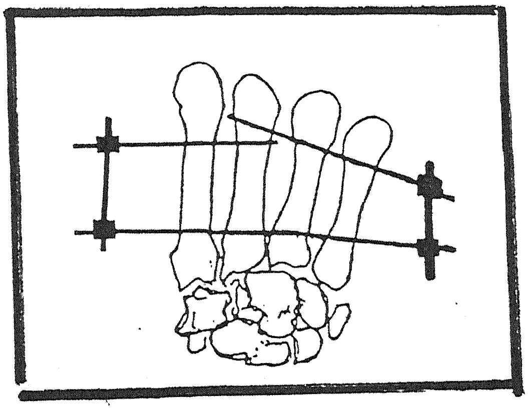
i) **Metacarpal segment** – K-wires are passed in the manner described for the syndactyly frame. Short connecting rods extending from the wrist to the MP joint level are fixed on either side.

ii) **Phalangeal segment** – Depending on the indication for use, the phalanges are anchored to the frame extensions either by nail sutures or by longitudinal K-wires in the terminal phalanx.

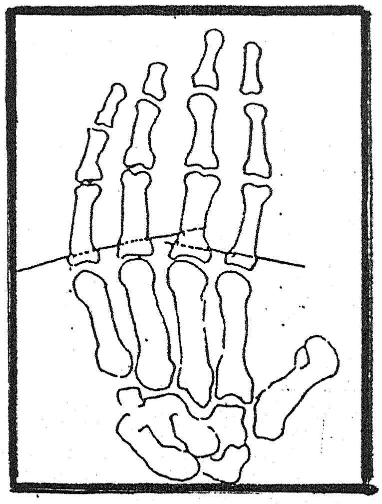
iii) **Hinges** – Two pairs of hinges are used for an extended hand frame. One frame is at the level of the wrist between metacarpals and forearm segments and the second pair is at the level of the MP joint between the metacarpal proximally & phalanges distally. Positioning of the wrist &MP joint is possible at any desired angle. In single positioning frame, hinges at the wrist level are not essential. A long connecting rod bent at the desired angle of wrist dorsiflexion (usually 15°-20°) is substituted for the hinges & fixes both forearm & metacarpal segments. When the MP joints are to be maintained in static



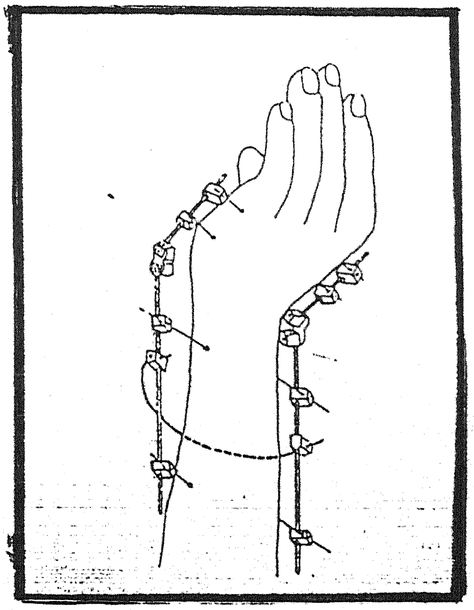
FOREARM HOLD



METACARPAL HOLD



PHALANGEAL HOLD



POSITIONAL HAND FRAME

SEGMENTS OF POSITIONAL HAND FRAME

flexion, the two connecting rods may be clamped together in a standard link joint.

11) STANDARD HAND FRAME:

The assembly has 4 basic sections:

1. *Metacarpals hold* - Metacarpal hold is pivotal, over which the frame is erected. The 2nd to the 5th metacarpals provide the fixation points for the assembly. One transverse k-wire transfixes the metacarpal through their basis &the two half pins are inserted near the neck of metacarpal, one each in the ulnar & radial metacarpals.

2. *Extension for positioning of the finger:-*

   The distal ends of the connecting rods connected to the two metacarpal pins are attached to transverse connecting rod & a rectangular frame is constructed from this horizontal bar.

   (a) 4(or less, as required) uprights bars are connected to the transverse bar for external fixation of fractures of individual fingers. The upright bars parallel the finger

   (b) Two upright bars & a horizontal bar between them to provide attachment for applying traction to the fingers.

(c) Or a uniaxial joint is attached to the upright bars for mobilization of the MP joints. These uniaxial joint can be locked in any desired position of the MP joints.

3) *Extension for the thumb ray*: A horizontal connecting rod raised from the radial upright bar is bent into a smooth arc & attached to pins in the first metacarpal. This allows the thumb to be fixed in the desired angle of palmar abduction & opposition by positioning the thumb anywhere along the arc.

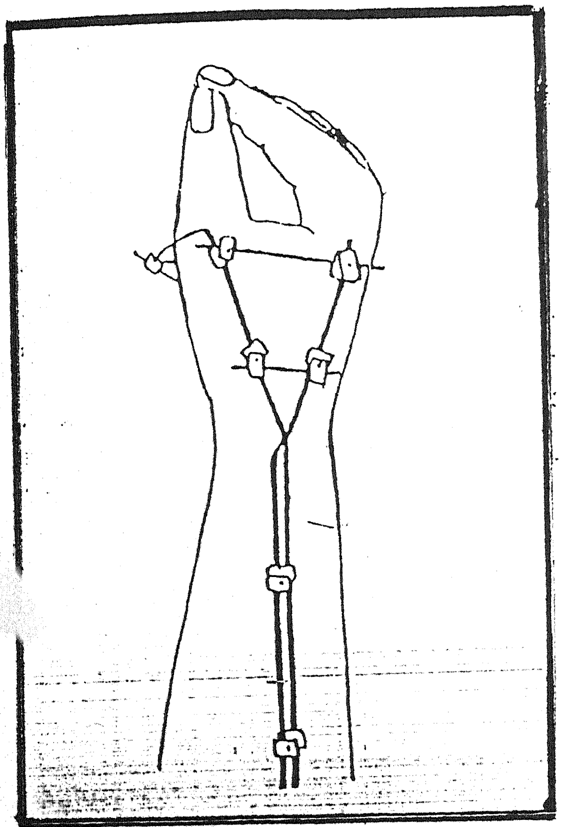
4) *Extension for the wrist & forearm*:

In cases, where the bases of the metacarpals or any the carpal bones are injured, it is desirable to immobilize the wrist completely. To achieve this, two half pins are passed into the radius & ulna, are each in the proximal & distal parts. These are connected to hand frame, applied along the medial & lateral borders of the forearm. The frame is further stabilized by semi-circular arc applied at suitable sites along the connecting rods.

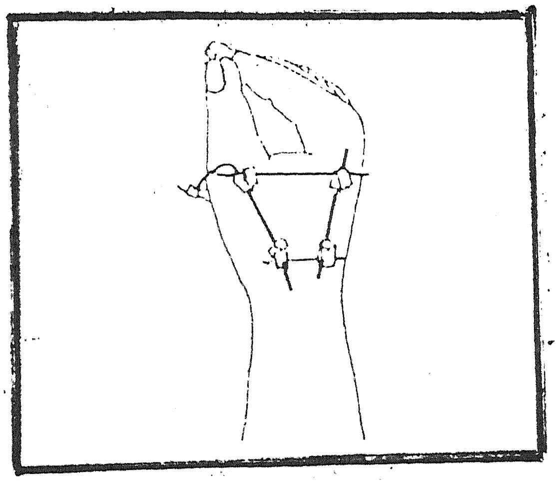
VARIATIONS OF STANDARD HAND FRAME

1 **Wrist positioning frame with first web space attachment:**

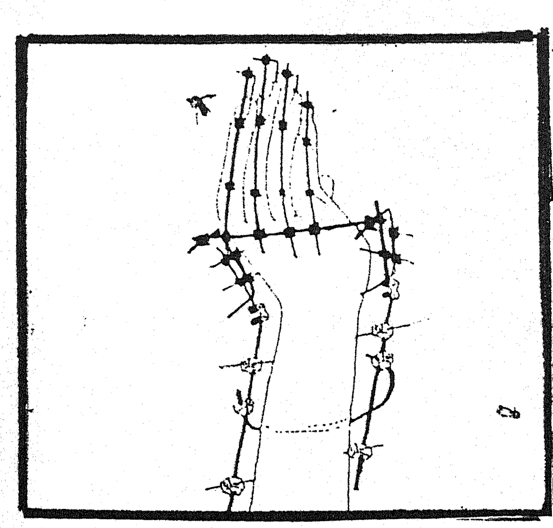
A pin Inserted into the 1st metacarpal is attached to the radial unilateral standard hand frame via a connecting rod. This opens up the 1st web space & keeps the thumb abducted & apposed.



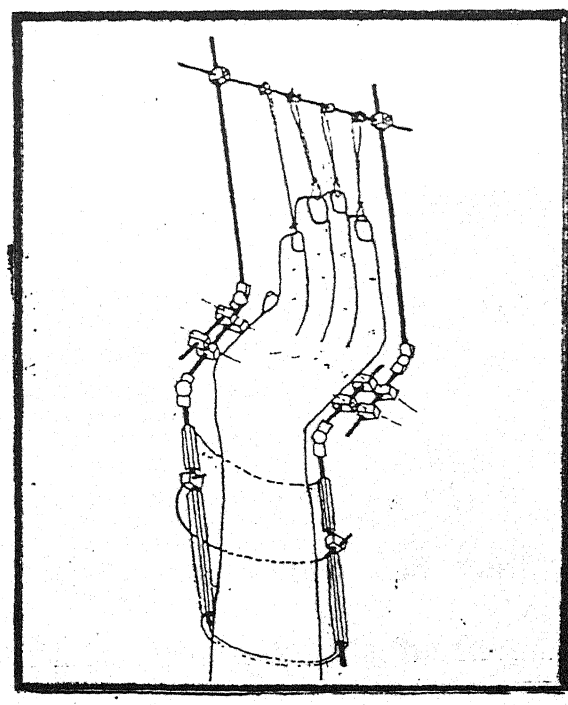
WRIST POSITIONING FRAME WITH FIRST WEB SPACE ATTACHMENT



FIRST WEB SPACE FRAME



MULTIPLE RAY EXTENSION TO FINGERS OF STANDARD HAND FRAME



FOREARM HOLD OF THE STANDARD HAND FRAME

2 **Multiple ray extension to fingers:** On a delta frame in forearm & wrist, multiple ray extension are provided as additional frame work for holding fractured fingers in alignment in a crushed hand.

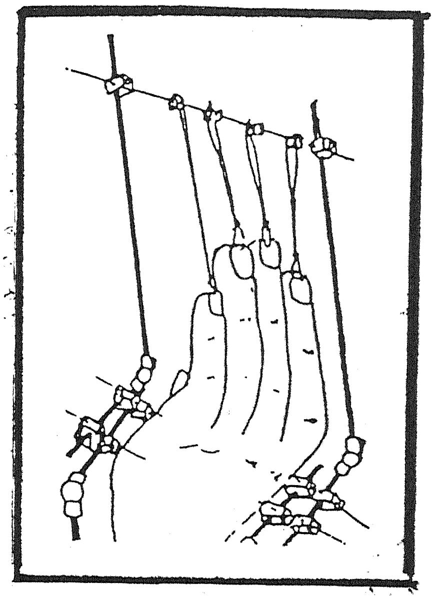
3 **Axial traction for immobilization**: This variation is used for mobilization of small joints of fingers. Axial traction through the traction bow is used for holding the IP joints in neutral position & MP joints flexion. Alternate flexion & extension at IP joints can also be carried out for establishing the mobility.

4 **Frame for pronation/supination movements**: Another useful modification is not to extend the connecting rod over to forearm on ulna aspect. In this pronation and supination movements are not restricted.

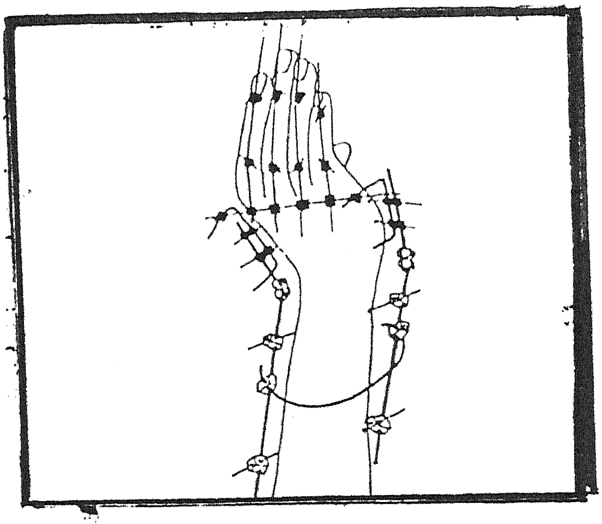
12) EXTENDED HAND FRAME

Indication - Crush injuries, degloving injuries and complex multiple fractures of the hand.

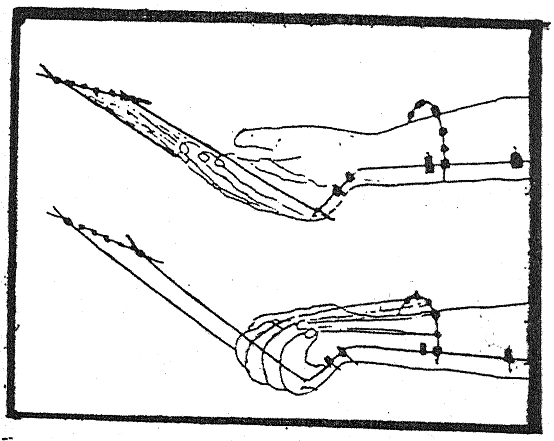
Frame construction – The basic frame is set up on the two transverse K-wires impaled from the radial side into the second and third metacarpals and two wires impaled from the ulnar side into the forth and fifth metacarpals. If the injury extends into the palm and wrist,



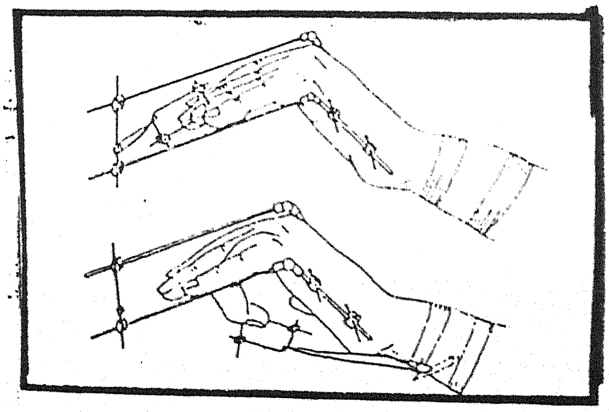
MP JOINTS MOBILIZATION ON
NAIL TRACTION BY RUBBER BAND



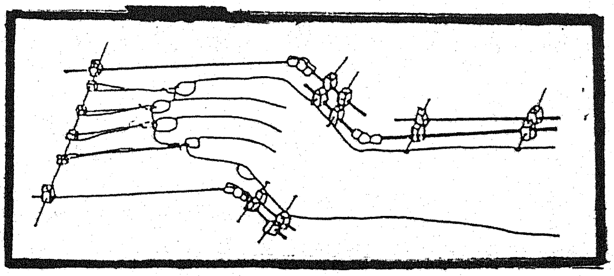
HAND & FOREARM FRAME WITH
MULTIPLE RAY EXTENSIONS TO
THE CRUSHED DIGITS



ASSEMBLY FOR ESTABLISHING
MOVEMENTS AT MP & IP JOINTS
WITH ALTERNATE CHANGE
OF POSITIONS



FRAMES FOR MOBILIZATIONS
OF DIGITS BY ALTERNATE
CHANGE OF ANCHOR POINTS
OF "L" FRAME



EXTENDED HAND FRAME FOR
PRONATION & SUPINATION
MOVEMENTS

the radius and the ulna are also included in the frame. Individual digits are immobilized by vertical K-wires through the distal phalanx or by nail traction, in cases where intact nail is present. Fractures of the individual phalanges are then hooked over the main frame with separate K-wires and connecting rods. Once the wounds have heal and is the fracture is stable, mobilization can be started by shifting the rubber bands to the "C" rod on the ulnar aspect of the forearm. Thus the frame itself can be used as a dynamic splint, not only for passive positioning but also for resistive exercises to strengthen the flexors and extensors.

POST OPERATIVE MANAGEMENT

1) Care of the frame -: The patient is bound to have pain & discomfort while the effects of the anaesthetic agents abate. The patients are often rowdy, & it is at this time that they may injure them selves with the frame. Thus all wires must be trimmed and only 4-5mm of the wire should be protruding beyond the link joints.
2) Assessment of vascularity status
3) Analgesic & anti inflammatory drugs
4) Antibiotics according to pus culture & sensitivity in compound injuries of hand.

5) Elevation- the injured limb must always be kept elevated above the level of the heart to facilitate gravitation of body fluids into the circulation. A sling, that encompasses the entire forearm to prevent constrictive bandage, is the best method of elevation. Intermittently the patient is advised to straighten the elbow & put the shoulder through a full range of movements.

6) Dressings :-

Closed injuries : - Dressings of the pin tracks are changed on the first and second post-op day. The pin tracks are cleaned with diluted cetrimide solution & also the entire hand & forearm. The pin tracks may be kept open without any dressings once the post operative oozing has ceased. In some patients with poor personal hygiene, each pin track is covered with gauze soaked in povidone iodine. The entire frame is covered in a gamgee.

Open injuries:-In open injuries, the dressings are changed every day or alternate day. The wounds are washed with copious amounts of water or saline. The hand can be immersed in a large basin of warm water with dilute cetrimide with povidone iodine solution or a simple Eusol wash can be given. The wound is lightly scrubbed with a soft & moist gauge piece. All scabs which are loose are removed, blisters punctured & slough & necrotic tissue are trimmed away

mechanically. Dressings are done after a final wash with saline. A layer of nonadhesive dressings of vaseline gauge is applied. A layer of povidone iodine soaked gauge piece may be used over it. Dressings are placed is such a way that there are no encircling bandages & the dressings are easily removable.

7) Mobilization:-

a) *Uninjured fingers & uninvolved segments of the injured fingers* – Mobilization of every joint, which is not involved in frame, should start from the very first day. In cases where there is no active mobility, passive mobilization should be carried out at regular interval.

b) *Mobilization of injured digits & immobilized joints:-* Injured digits & immobilized joints are mobilized usually after three weeks of procedure. It must be ascertained that the fractures are stable & that the healing is progressing satisfactorily. All wounds should have healed prior to starting mobilization. If the wounds are extensive or the fractures are unstable at the end of three weeks, it is better to defer the mobilization for a further period of a week.

c) *Conversion of frame into a dynamic frame*:- In some of the injuries which involve the hand & the wrist, the frame may be

retained after the fractures have united & the wounds have healed. Hinges can be incorporated into the frame at the level of the wrist or the MP joints & guarded motion begun.

8) Frame removal: - Frame removal is done with the patient lying down. In young children, or in cases of extremely apprehensive patients, this may have to be performed under anaesthesia. After removal of all the k-wires, the pin tracks are squeezed & pinched up until something "gives" & the mouth of the tract pouts outwards. Indrawn pin tracts, when troublesome may have to be excised & the wound sutured afresh after undermining around the wound. Immediate post removal splintage may be necessary with a splint or a POP slab or cast for two to three days till the swelling & pain disappears.

The frame could be removed after the fracture has united or the wound has healed whichever is later. At three weeks, a radiological examination followed by renewal of the critical connecting rods & clinical testing for union should be done. If there is no abnormal mobility or undue pain, the frame may be removed.

9. Follow-up: -

Patients are followed up at two weekly intervals till two month to two and half months after fixator removal.

Main aim of follow up : -

- Assessment of functions
- Stability of apparatus
- Complication, if any
- Advise regarding physiotherapy
- To see for union

<u>Results will be evaluated on the criteria's laid down: -</u>

Difference in AROM [average range of motion] at MP joint, PIP joint, DIP joint, wrist joint & Grip strength.

Difference in AROM at MPJ, IPJ &PIPJ

Diff. In AROM	Points
No difference	4
0-30°	3
30-60°	2
>60°	1

Difference in AROM at DIP joint

Diff. in AROM	Points
No difference	4
0-15°	3
15-30°	2
>30°	1

Difference in AROM at DIP joint

Diff. in AROM	Points
No difference	4
0-50°	3
50-100°	2
>100°	1

Grip strength as compared to normal hand

Grip strength	Points
Normal	4
Mild deficiency	3
Moderate ”	2
Severe ”	1

Results

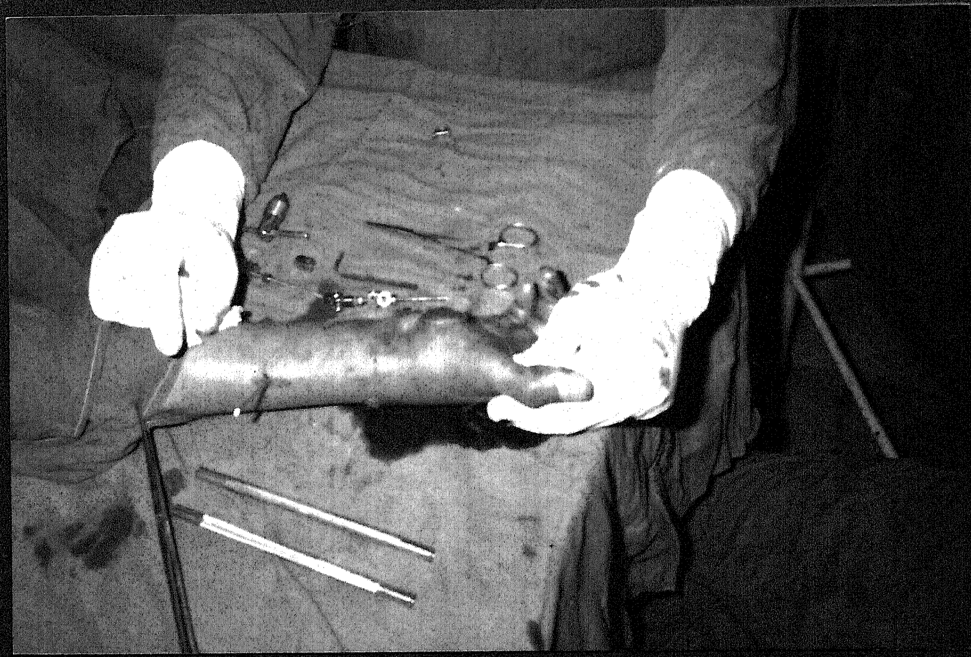
Results	Points
Excellent	52-64
Good	40-51
Fair	28-39
Poor	16-27

Photograph -1: Showing instrument used in JESS fixation from left to right-- Manual hand drill, T-handle with chuck, Maxpage, Wire-cutter, Needle-holder, Allies forceps, various Artery-forceps, BP-handle and Toothed forceps.

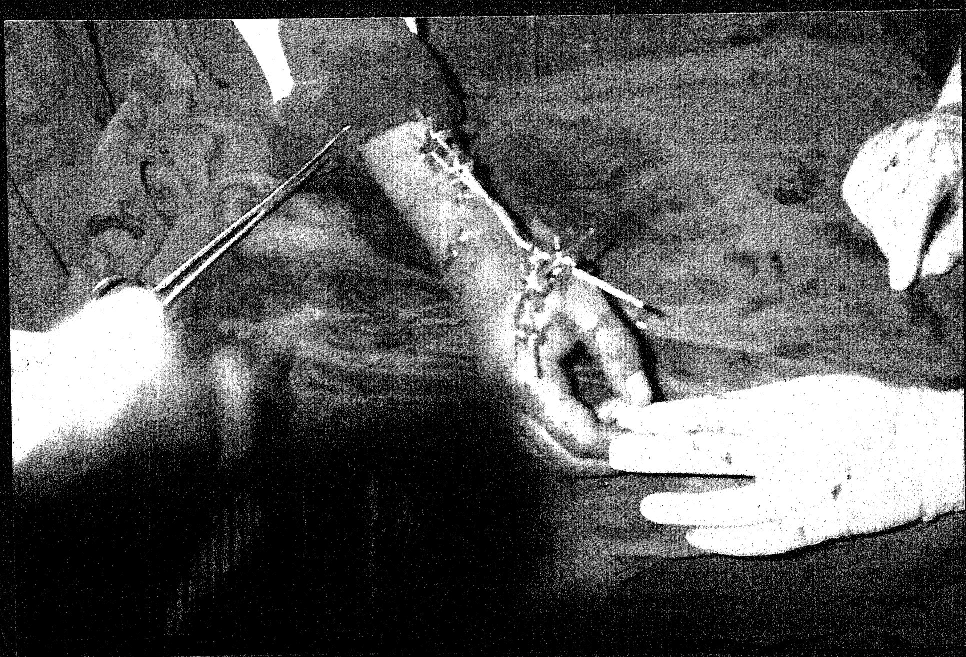
Photograph – 2: Showing various components of JESS frame from above downwards- Spanners, Bender tubes, Different distractors, Link-joints, K-wires, Connecting rods and Allen keys.

Photograph – 3: Showing comminuted fracture of the first metacarpal with involvement of CM joint.

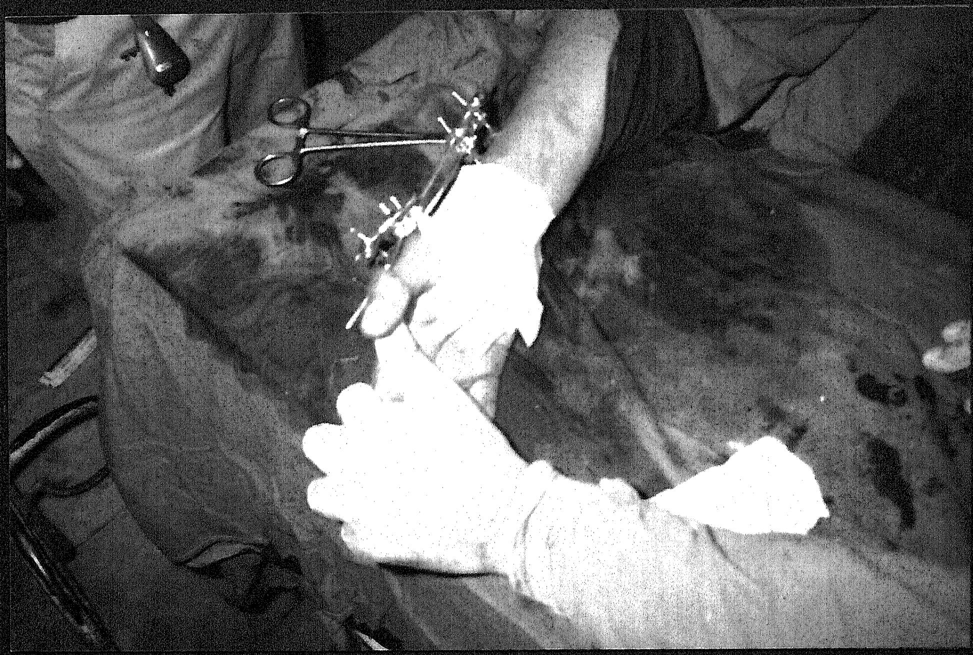
Photograph – 4: Showing compounding of the fracture in above case, with involvement of first web space.



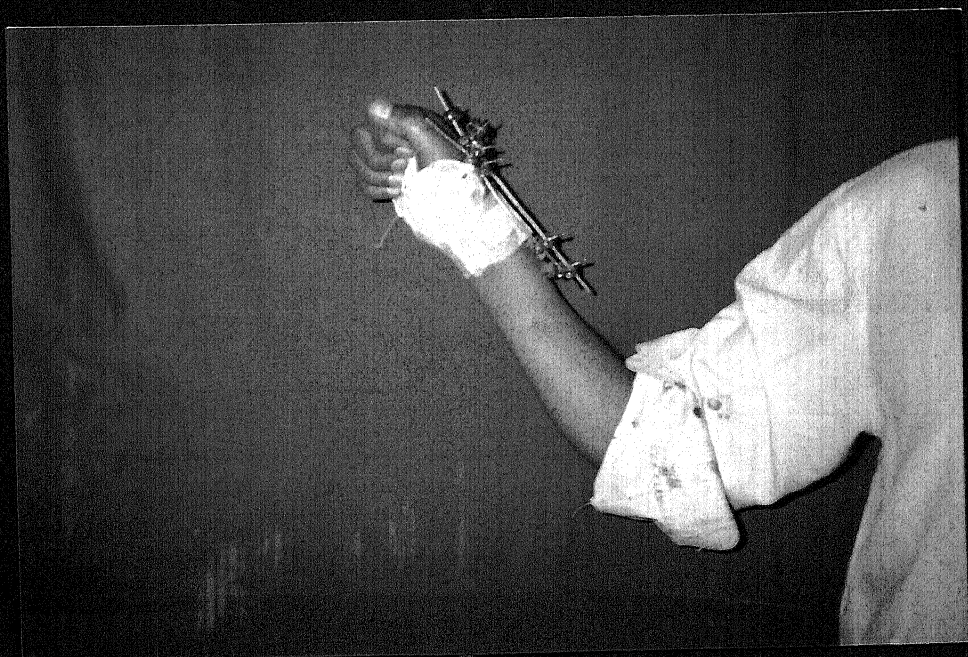
Photograph – 5: Showing position of k-wire, during operative procedure.



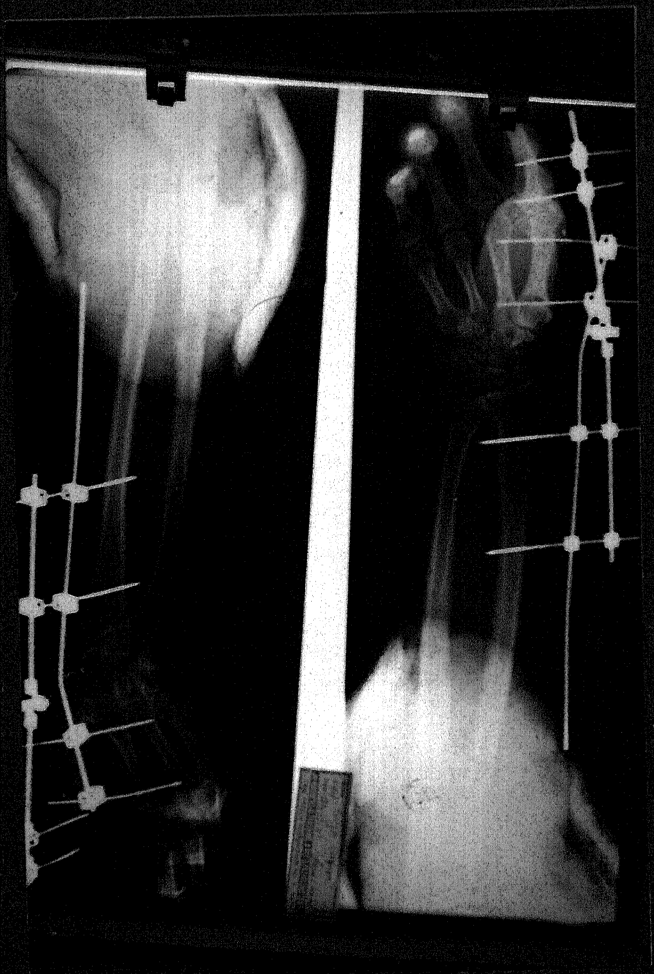
Photograph- 6: Finally constructed first web space frame, after fracture reduction.



Photograph- 7: Post-operatively condition of the injured hand after dressing.



Photograph- 8: Patient having full movements of hand, on the first post-operative day.



Photograph-9: Post-operative check x-ray of the patient.

Photograph-10: Patient had full grip-strength, after fixator removal with excellent results.

OBSERVATIONS

OBSERVATION

The study is based on the observations of 40 cases of Hand and forearm injuries admitted in Department of Orthopaedics, MLB Medical College, Jhansi.

In this prospective study, an attempt has been made to study the role of JESS in hand and forearm injuries, the complications arises during treatment and their management.

The study was conducted on 40 patients of hand and forearm injuries, 36 were male and 4 were female among them. We included patients with all kinds of injuries, 34 have open type and rest 6 has closed type injury. Majorities of open type wounds were crushed. Maximum number of patients present on the same day of injury chiefly and majority of patients comprises between 25-40 years of age.

The patients were kept on the A/E POP slab, after clean and dressing of wound preoperatively till the fixator is applied.

Physiotherapy was started on the 1^{st} or 2^{nd} post operative, as per pain tolerance and cooperation of patient.

TABLE NO. – 1

INCIDENCE IN DIFFERENT AGE GROUPS

Age in yrs.	Male		Female	
	No.	Percentage	No.	Percentage
10-20	06	16.67	--	--
21-30	12	33.33	1	25.00
31-40	14	38.89	1	25.00
41-50	03	08.33	--	--
51 & above	01	02.78	2	50.00
Total	36	100.00	4	100.00

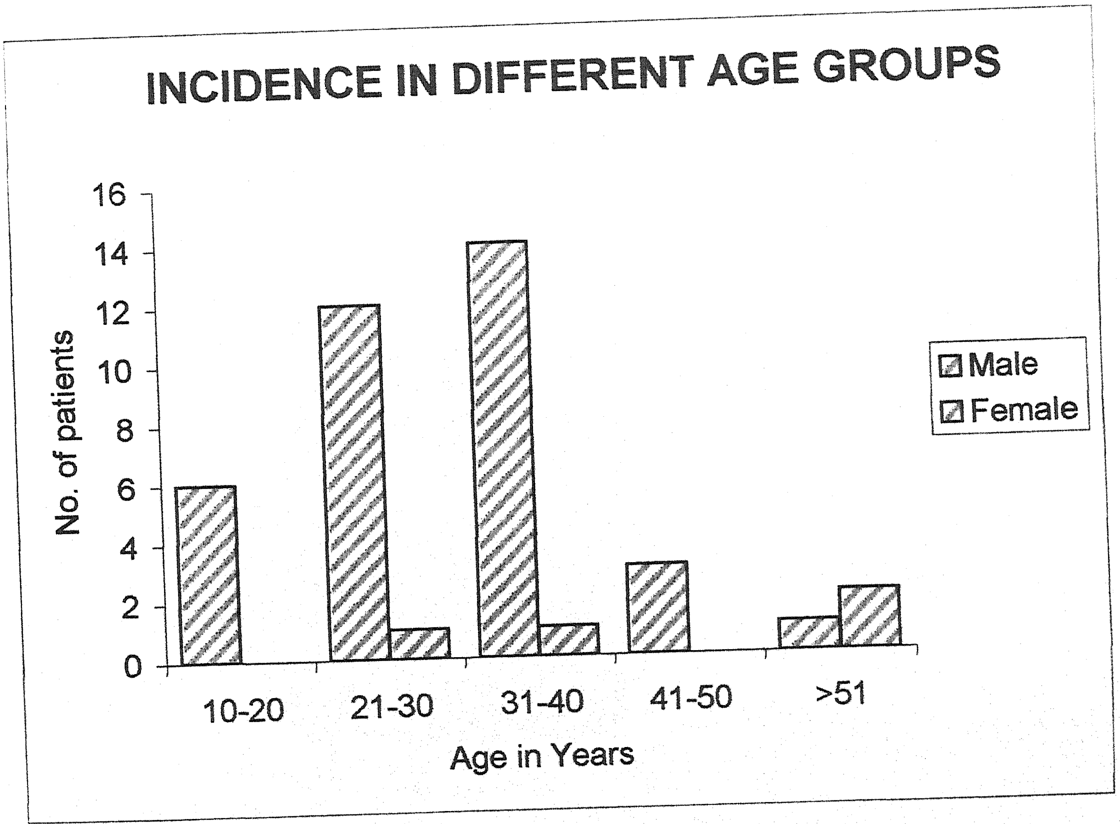
The incidence of injury was varying in different age groups. Majority of male patients were between 31-40 years of age, while female patients were >50 years of age. The mean age in our study was 32 years.

TABLE NO. – 2

(SEX INCIDENCE IN TOTAL PATIENTS)

Sex	No. Of cases	Percentage
Male	36	90.0
Female	4	10.0
Total	40	100

There were 36 males (90%)& 4 females (10%) included in the study.


INCIDENCE IN DIFFERENT AGE GROUPS
No. of patients
0
2
4
6
8
10
12
14
16
10-20
21-30
31-40
41-50
>51
Age in Years
Male
Female

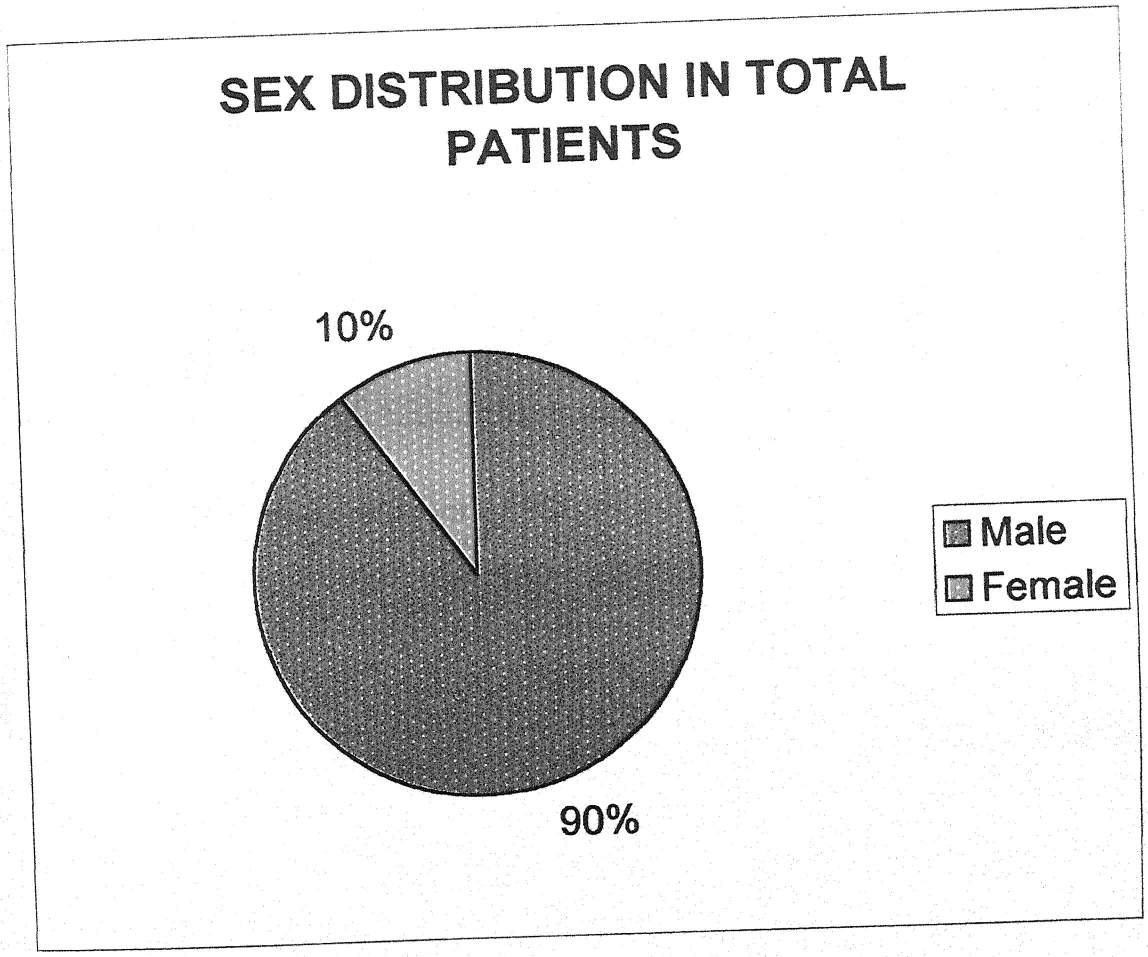

SEX DISTRIBUTION IN TOTAL PATIENTS
10%
90%
Male
Female

TABLE NO –3

(DURATION OF INJURY IN DIFFERENT CASES)

S. No.	Duration	Cases	Percentage
1	< 1 day	22	55.0
2	1-5 day	14	35.0
3	6-10 day	02	5.0
4	11-15 day	01	2.5
5	16-30 day	--	--
6	31-90 day	--	--
7	> 90 day	01	2.5
	Total	40	100

Maximum number (55%) of patients present on the same day of injury while 90% of patients present with in 5 days of injury.

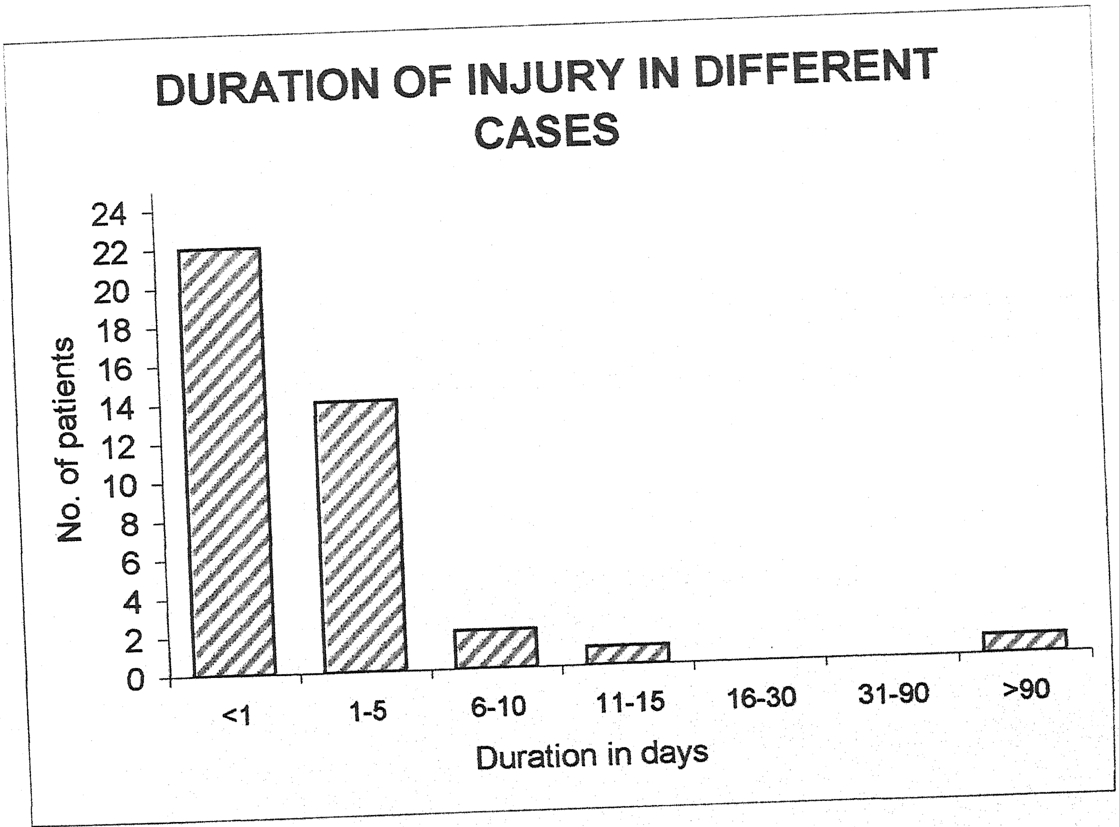

DURATION OF INJURY IN DIFFERENT CASES
No. of patients
0
2
4
6
8
10
12
14
16
18
20
22
24
<1
1-5
6-10
11-15
16-30
31-90
>90
Duration in days

TABLE NO-4

(MODE OF INJURY IN DIFFERENT CASES)

S. No.	Mode of injury	No. of patients	Percentage
1.	Thresher or machine injury	10	25.0
2.	Road traffic accidents	10	25.0
3.	Fall of heavy objects	08	20.0
4.	Fire- arm injury	05	12.5
5.	Blast injury	02	05.0
6.	Others	05	12.5
Total		40	100.0

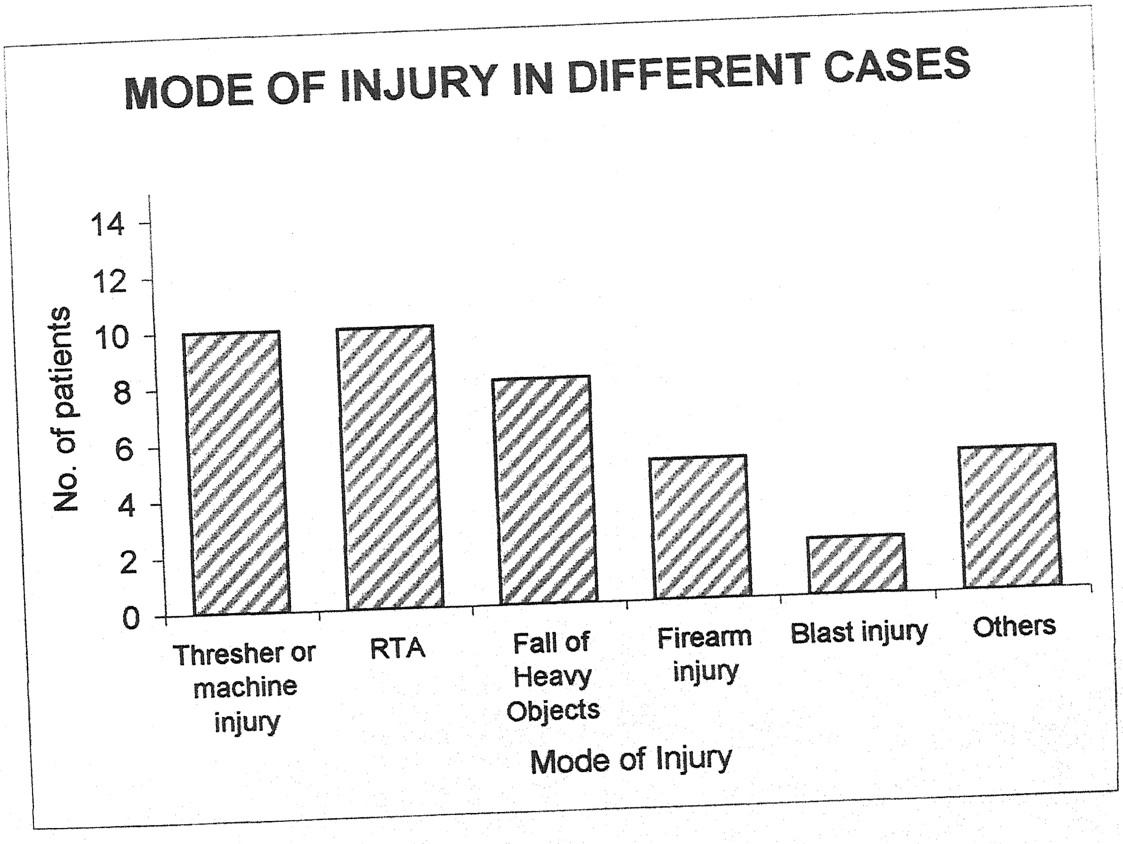
Most common mode of injury in our study was thresher injury & road traffic accident followed by fall of heavy objects.

TABLE NO. 5

TYPE OF WOUND

Type of wound	No. Of patients	Percentage
Crushed	18	52.94
Lacerated	15	44.12
Incised	01	02.94
Total	34	100.00

Wounds were crushed in 53% patients 53% while lacerated in 44% of cases.


MODE OF INJURY IN DIFFERENT CASES
No. of patients
14
12
10
8
6
4
2
0
Thresher or machine injury
RTA
Fall of Heavy Objects
Firearm injury
Blast injury
Others
Mode of Injury

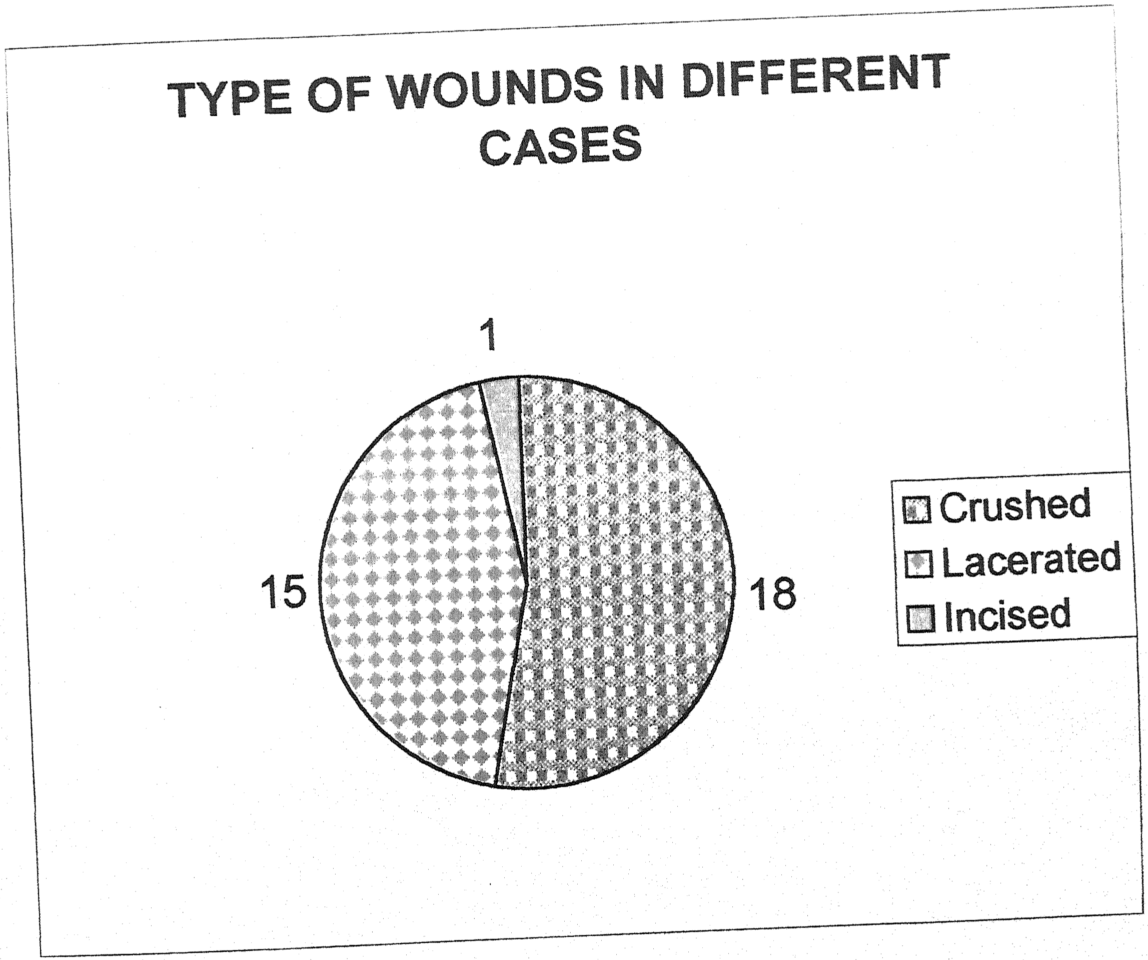

TYPE OF WOUNDS IN DIFFERENT CASES
1
15
18
Crushed
Lacerated
Incised

Table No. – 6

(Condition of Injured Part)

S. No.	Condition	No. of cases	Percentage
1.	Open	34	85
2.	Closed	06	15
Total		40	100

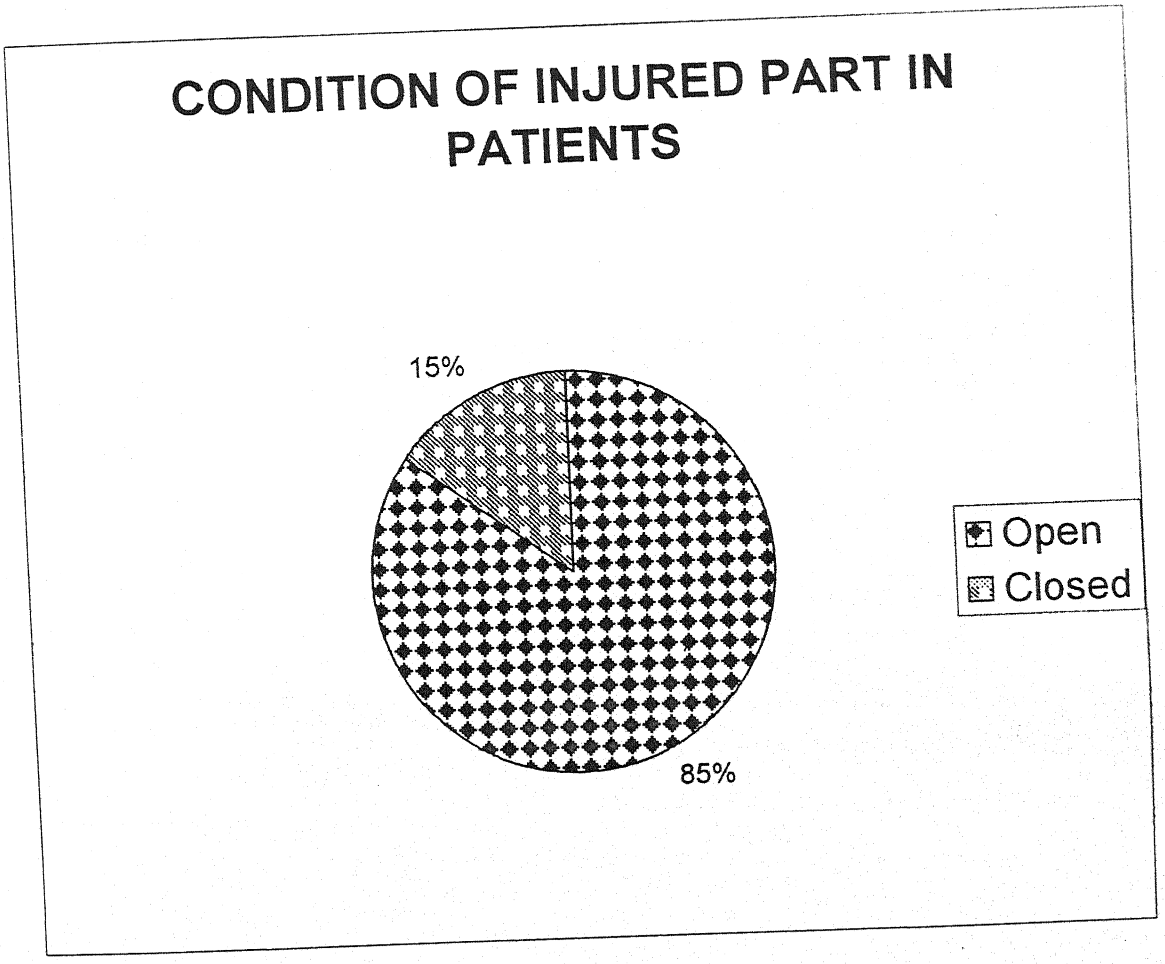
Out of 40 patients, 34 patients (85%) have open type fracture.

Table No. –7

Severity of Wound

Grade	I	II	III
Cases	01	14	19

Out of 34 patients having open type fractures, 19 have type III compounding.


CONDITION OF INJURED PART IN PATIENTS
15%
85%
Open
Closed

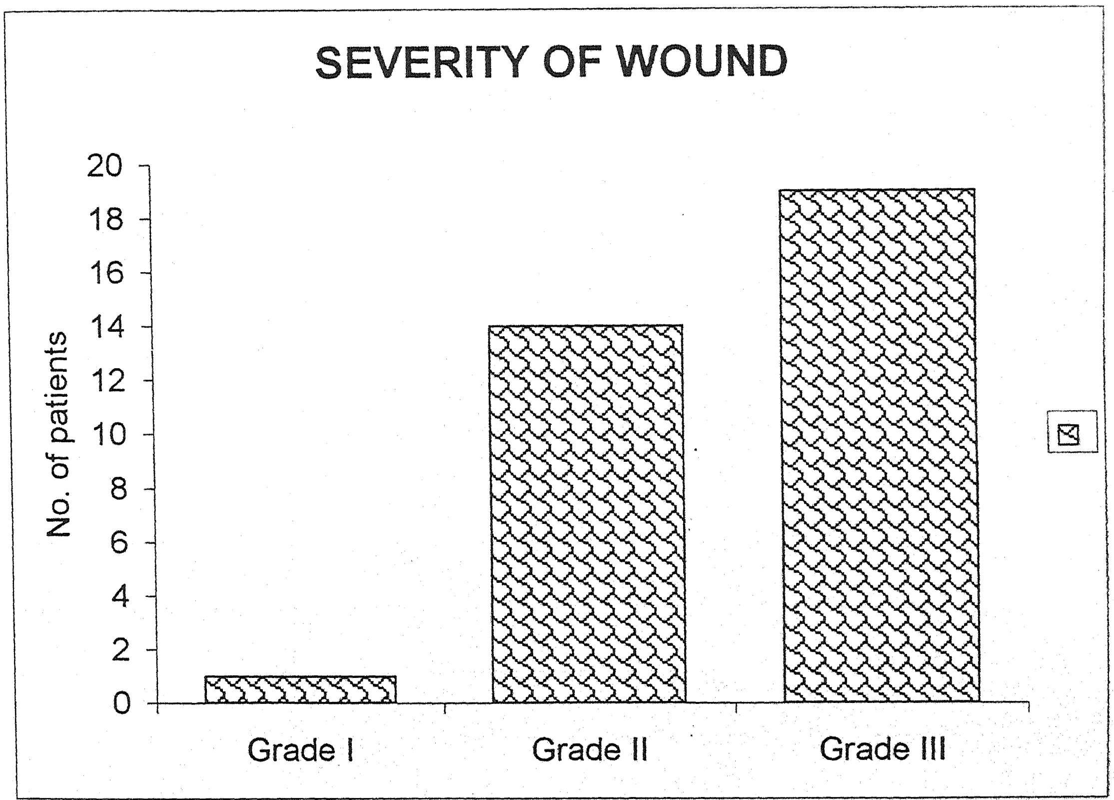

SEVERITY OF WOUND
No. of patients
0
2
4
6
8
10
12
14
16
18
20
Grade I
Grade II
Grade III

TABLE NO. – 8A

PATTERN OF INVOLVEMENT OF BONES AMONG PATIENT.

S. No.	Bones involved	No. of patients	Percentage
1	Both bone forearm	04	10.0
2	Metacarpal	09	22.5
3	Phalanges	13	32.5
4	Combined	14	35.0
Total		40	100.0

More then one group of bones were involved in 35% of cases in our study, while isolated fractures of phalanges & metacarpal were present in 32.5 & 22.5%of cases, respectively.

TABLE NO. – 8B

S. No.	Bones involved	No of fractures	Percentage
1.	Phalanges	32	32
2.	Metacarpal	50	50
3.	Radius	09	09
4.	Ulna	09	09
Total		100	100

Metacarpals fractured in maximum cases of combined injury that's why metacarpals share 50% of total no of bone fractured in our study.

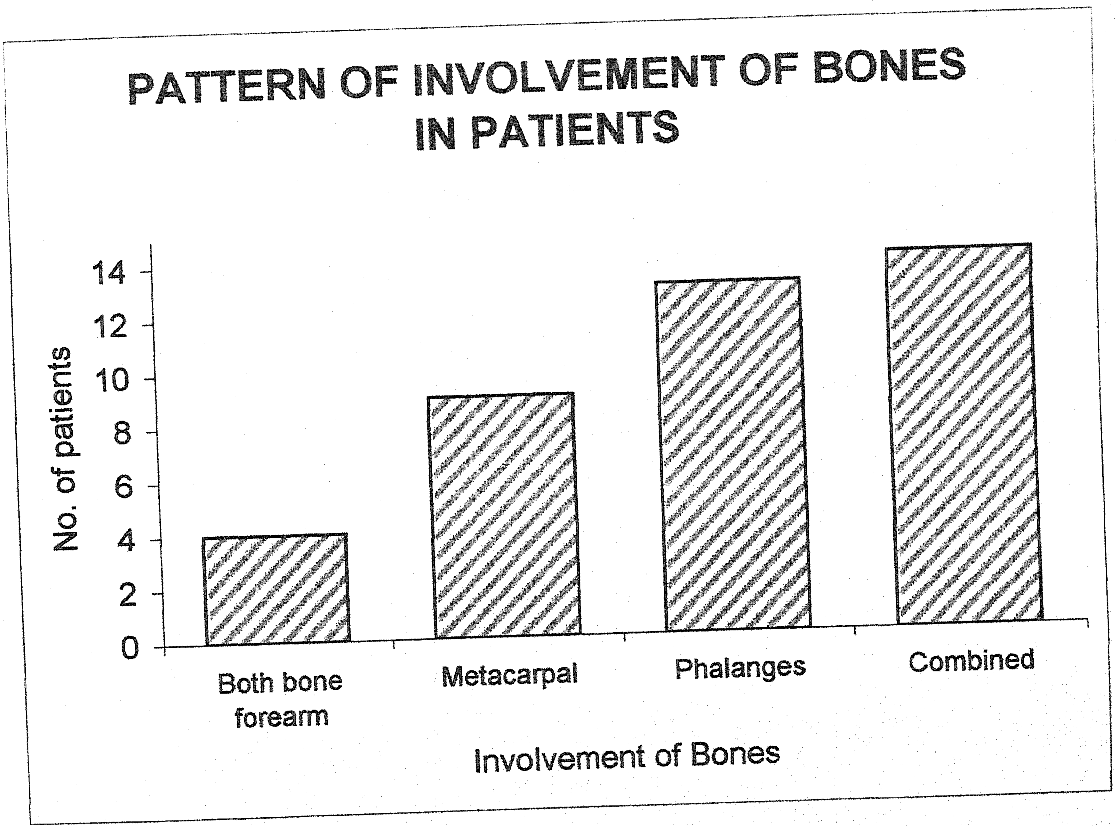

PATTERN OF INVOLVEMENT OF BONES IN PATIENTS
No. of patients
0
2
4
6
8
10
12
14
Both bone forearm
Metacarpal
Phalanges
Combined
Involvement of Bones

TABLE NO. – 9

PATTERN OF JOINT INVOLVEMENT AMONG PATIENTS

S. No.	Joint involved	No. of joints involved	Percentage
1.	MP	16	34.78
2.	PIP	04	08.70
3.	DIP	03	06.52
4.	IP	07	15.22
5.	WT	16	34.78
	Total	46	100.0

MP joint & wrist joints were commonly involved joints in our study because metacarpals were involved in large number.

TOTAL NO. – 10

TYPE OF JESS FRAME APPLIED IN ALL PATIENTS

S. No.	Type of JESS frame	No. of cases	Percentage
1.	Distractor	11	27.5
2.	Extended hand frame	05	12.5
3.	Basic hand frame	04	10.0
4.	Ray frame	04	10.0
5.	1^{st} web space frame	04	10.0
6.	Forearm frame	02	5.0
7.	" U"/"L" frame	04	10.0
8.	Metacarpal hold	04	10.0
9.	Biplanner frame	01	2.5
10.	Bennett's fracture frame	01	2.5
Total		40	100.0

Various types of JESS frame were applied in our study, but different distracters (29.5%) were applied commonly.

TABLE NO. – 11

COMPLICATION

S. No.	Complications	No.	Percentage
1.	Pin tract infections	04	10.0%
2.	Osteomyelitis	06	15.0%
3.	Deformity	18	45.0%
4.	Non- union	03	7.5%
5.	Delayed- union	02	5.0%
6.	Swelling	10	25.0%
7.	Skin- necrosis	08	20.0%
8.	Pain	10	25.0%
9.	Loosening of joints	02	5.0%
10.	Loosening of k-wires	05	12.5%
11.	Contractures	01	2.5%

The most common complication encountered in our study was deformity in 45% of cases followed by swelling and pain.

TABLE NO. – 12

(OPERATION PROCEDURE REQUIRED IN MANAGEMENT)

S. No.	Operation/ procedure required	No.	
1.	Debridement & ext. fixation without distraction	26	65.0%
2.	Debridement & ext. fixation with distraction	08	20.0%
3.	Distraction/ compression	12	30.0%
4.	POP immobilization	19	47.5%
5.	Split thickness skin grafting	04	10.0%
6.	Bone grafting	03	7.5%
7.	Internal fixation	08	20.0%
8.	Sequestrectomy	06	15.0%
9.	Tendon repair	08	20.0%
10.	Myoplasty	04	10.0%
11.	Cortracture release/ Z-plasty	01	2.5%
12.	Corrective osteotomy	02	5.0%

TABLE NO. – 13

(CONDITION OF WOUND AT THE TIME OF REMOVAL OF FIXATOR)

S. No.	Status	No.	Percentage
1.	Healed	29	75.50
2.	Not healed	11	27.50
Total		40	100.00

In 72.5% of cases fixator was removed after complete healing of wound while in 27.5% cases it was removed before healing of wound.

TABLE NO. – 14

(TIME OF FIXATOR REMOVAL)

S. No.	Duration in days/ wks/ months	Cases	Percentage
1.	Less than < 28 days (4 wks)	05	12.5
2.	29-42 days (up to 6 wks)	15	37.5
3.	43-60 days (up to 2 months)	11	27.5
4.	60-90 days (up to 3 months)	05	12.5
5.	> 90 days (> 3 months)	04	10.0
Total		40	100.00

In 50% of cases fixator was removed with in 6 weeks while in 78% cases it was removed in 8 weeks of fixator application.

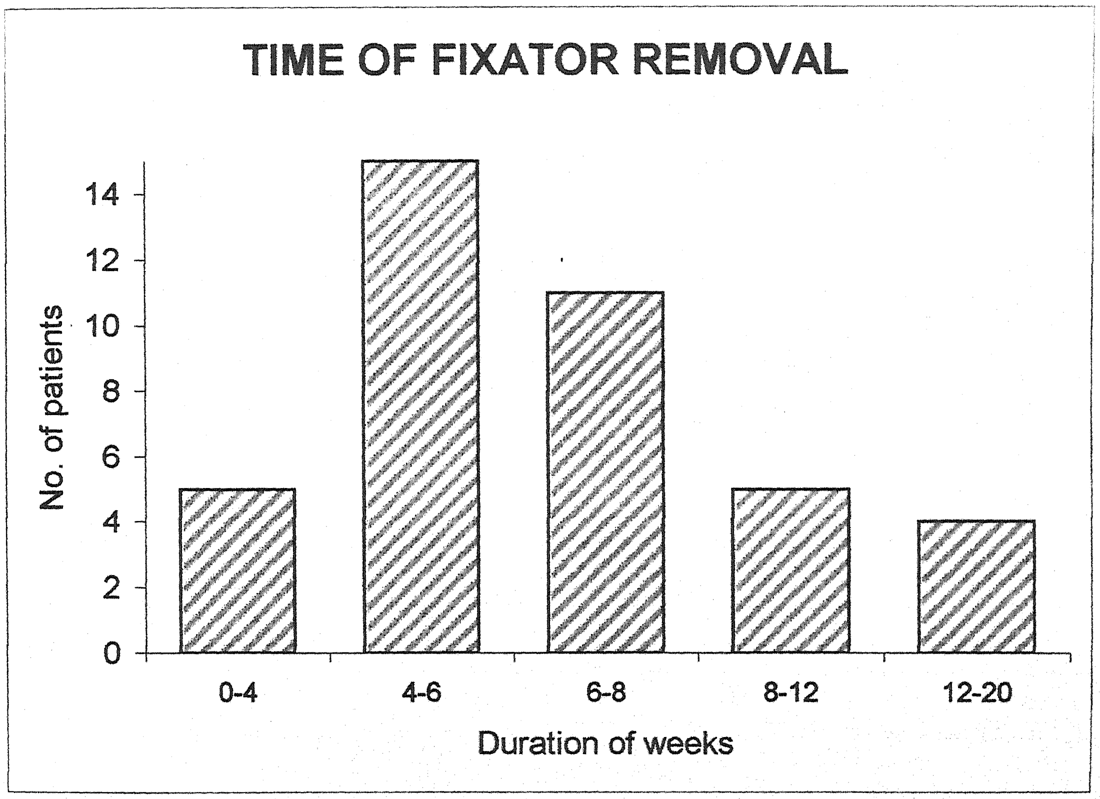

TIME OF FIXATOR REMOVAL
No. of patients
0
2
4
6
8
10
12
14
0-4
4-6
6-8
8-12
12-20
Duration of weeks

TABLE NO. – 15

(TIME OF WOUND HEALING)

S. No.	Duration	Cases	Percentage
1	Upto15 days	06	17.65
2	15-30 days	13	38.24
3	30-60 days	07	20.59
4	60-90 days	04	11.76
5	>90 days	04	11.76
TOTAL		34	100.00

Wounds were healed in 48% of cases with in 30 day.

TABLE NO. - 18

(PERIOD OF HOSPITALISATION)

S. No.	Duration in days	Cases	Percentage
1.	< 3	06	15.0
2.	4-7	07	17.5
3.	8-14	10	27.5
4.	15-30	13	30.0
5.	> 30	04	10.0
Total		40	100.00

Maximum numbers of patients were discharged with in 30 days of hospitalization.

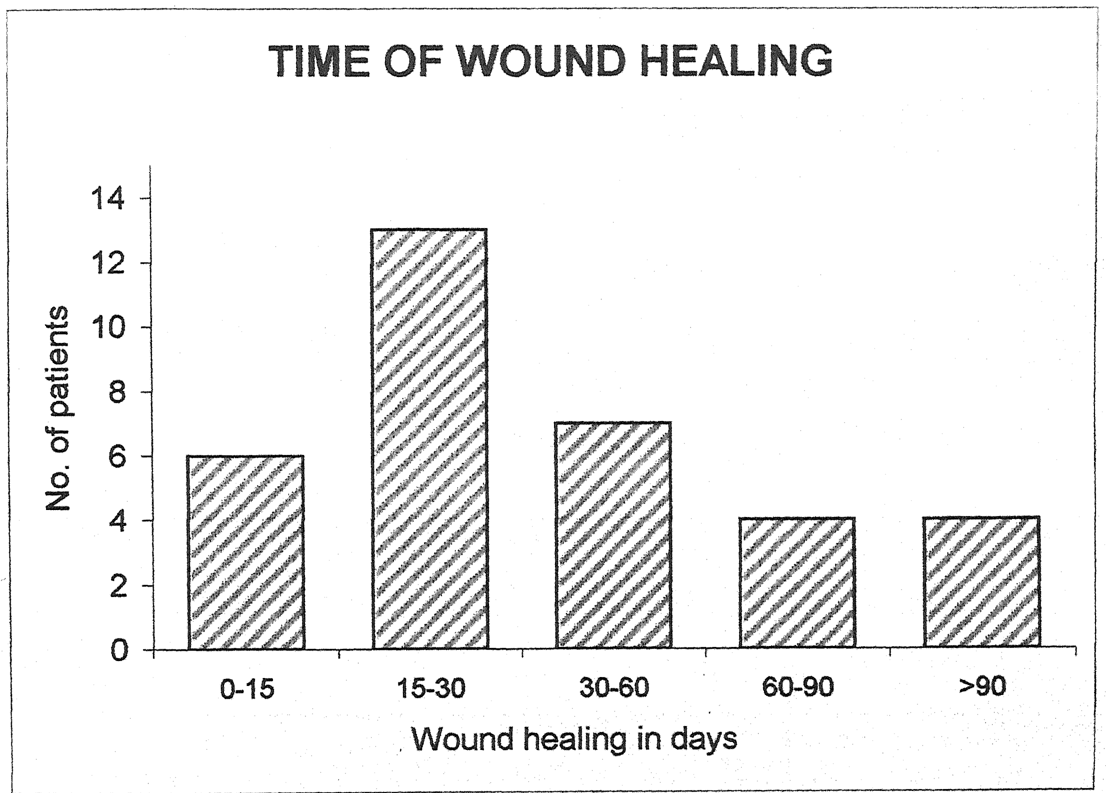

TIME OF WOUND HEALING
No. of patients
14
12
10
8
6
4
2
0
0-15
15-30
30-60
60-90
>90
Wound healing in days

TABLE NO. – 17

(RESTRICTIONS IN RANGE OF MOVEMENTS OF MP JOINT AT THE TIME OF FIXATOR REMOVAL)

S. No.		1.	2.	3.	4.	5.
1.	No difference	12	14	19	20	20
2.	0-30°	16	11	09	08	08
3.	30-60°	10	10	08	08	07
4.	60-90°	02	05	04	04	05

At the time of fixator removal full movements were regained at 42.5% of MP joints.

Table no. – 18

(RESTRICTIONS OF RANGE OF MOVEMENTS AT IP JOINT OF THUMB AT THE TIME OF FIXATOR REMOVAL)

S. No.		
1.	No difference.	17
2.	0-30°	08
3.	30-60°	08
4.	60-90°	07

At the time of fixator removal full movements were regains in 42.5% IP joint.

TABLE NO. – 19

(RESTRICTION IN RANGE OF MOVEMENTS AT PIP JOINT AT THE TIME OF FIXATOR REMOVAL)

S. No.		2.	3.	4.	5.
1.	No difference	16	21	23	23
2.	0-30°	11	09	06	07
3.	30-60°	08	06	07	04
4.	60-90°	05	04	04	06

At the time of fixator removal 51.88% of PIP joints regained full movements.

TABLE NO. – 20

(RESTRICTION IN RANGE OF MOVEMENTS AT DIP JOINT AT THE TIME OF FIXATOR REMOVAL)

S. No.		2.	3.	4.	5.
1.	No difference	17	25	24	25
2.	0-15°	15	09	10	08
3.	15-30°	-	01	01	-
4.	30-45°	08	05	05	07

At the time of fixator removal full movements were regained by 56.88% of DIP joints.

TABLE NO. – 21

(RESTRICTION IN RANGE OF MOVEMENTS AT WRIST JOINT AT THE TIME OF FIXATOR REMOVAL)

S. No.		
1.	No difference	16
2.	0-50°	07
3.	50-100°	10
4.	> 100°	07

At the time of fixator removal 40% of wrist joints regained full movements.

TABLE NO. – 22

(RESTRICTION IN RANGE OF MOVEMENT OF MP JOINT AT THE TIME OF FINAL FOLLOW-UP)

S. No.		1	2	3	4	5
1.	No difference	22	17	21	21	21
2.	0-30°	16	18	15	15	14
3.	30-60°	-	03	02	02	03
4.	60-90°	02	02	02	02	02

At the time of final follow up, 51% of MP joints regained full movements.

TABLE NO. – 23

(RESTRICTION IN RANGE OF MOVEMENTS AT IP JOINT OF THUMB AT THE TIME OF FINAL FOLLOW-UP)

S. No.		
1	No difference	27
2	0-30°	08
3	30-60°	03
4	60-90°	02

At the time of final follow up 67.5% of IP joints regained full movements.

TABLE NO. – 24

(RESTRICTION IN RANGE OF MOVEMENTS AT PIP JOINT AT THE TIME OF FINAL FOLLOW-UP)

S. No.		2	3	4	5
1	No difference	26	28	28	29
2	0-30°	08	07	07	04
3	30-60°	04	03	03	05
4	60-90°	02	02	02	02

At the time of final follow up 69.38% of PIP joint regained full movements.

TABLE NO. – 25

(RESTRICTION IN RANGE OF MOVEMENTS AT DIP JOINT AT THE TIME OF FINAL FOLLOW-UP)

S. No.		2	3	4	5
1.	No difference	27	31	30	31
2.	0-15°	08	06	07	04
3.	15-30°	02	01	01	03
4.	30-45°	03	02	02	02

At the time of final follow up 74.38% of DIP joint regained full movements.

TABLE NO. – 26

(RESTRICTION IN RANGE OF MOVEMENTS AT WRIST JOINT AT TIME OF FINAL FOLLOW-UP)

S. No.		
1.	No difference	23
2.	0-50°	11
3.	50-100°	03
4.	> 100°	03

At the time of final follow up 57.5% of wrist joints regained full movements.

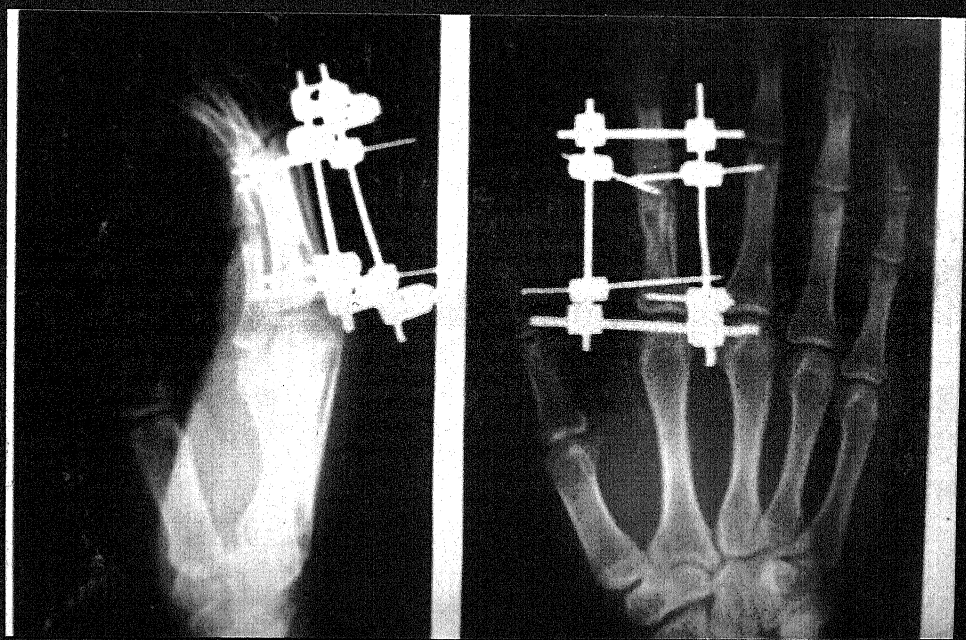
Table No. - 27

(GRIP STRENGTH AT FINAL FOLLOW-UP)

S. No.	Grip strength	Cases	Percentage
1	Normal	20	50.0
2	Mild deficient	12	30.0
3	Moderate deficient	06	15.0
4	Severely deficient	02	05.0
Total		40	100.00

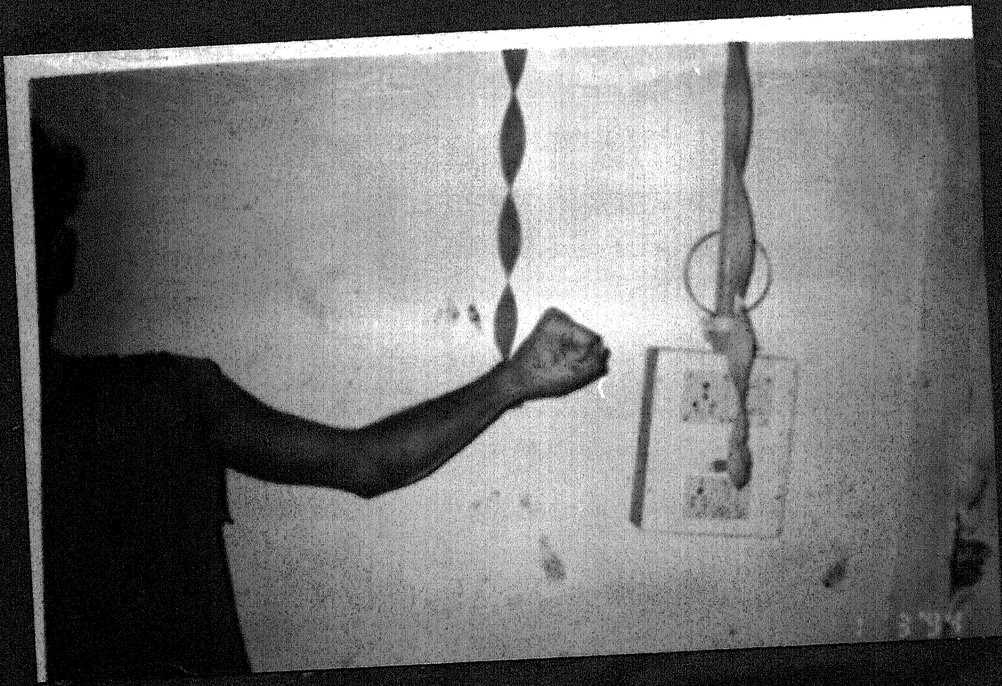
The grip strength at final fallow up was Normal in 50% of cases while mildly deficient in 30% of cases.

Photograph-11: Showing x-ray of a patient, having comminuted fracture of the proximal phalanx of index finger.



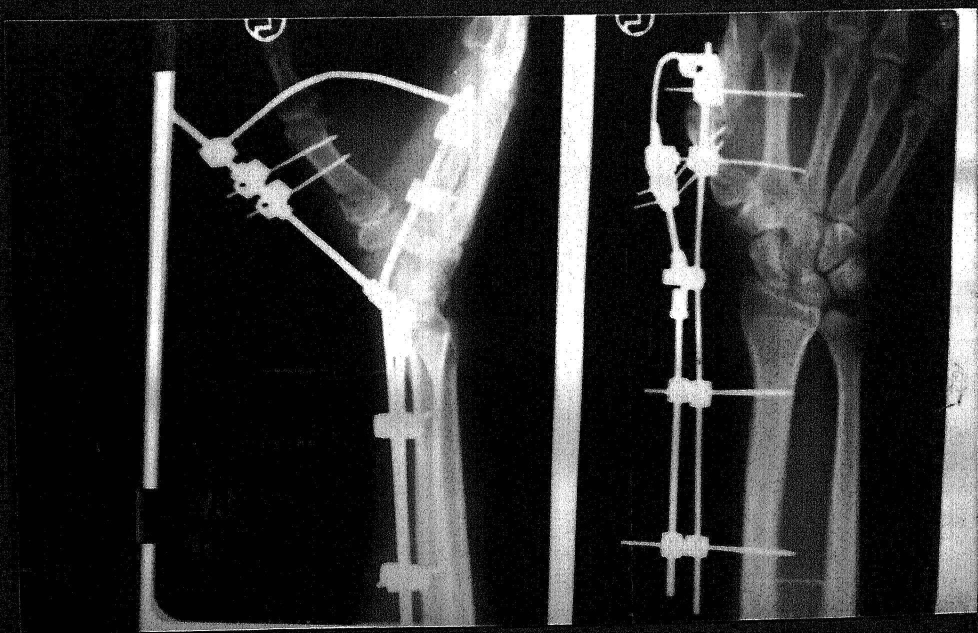
Photograph- 12: Showing x-ray of same patient with reduction of fracture after application of bilateral frame.

Photograph-13 & 14: Showing full movements of the injured hand in same patient, with fixator in position.



Photograph 15 & 16: Showing full movements of the injured hand in same patient, after fixator removal, with excellent results.

Photograph 17: Showing x-ray of a patient having bennett's fracture after road traffic accident.



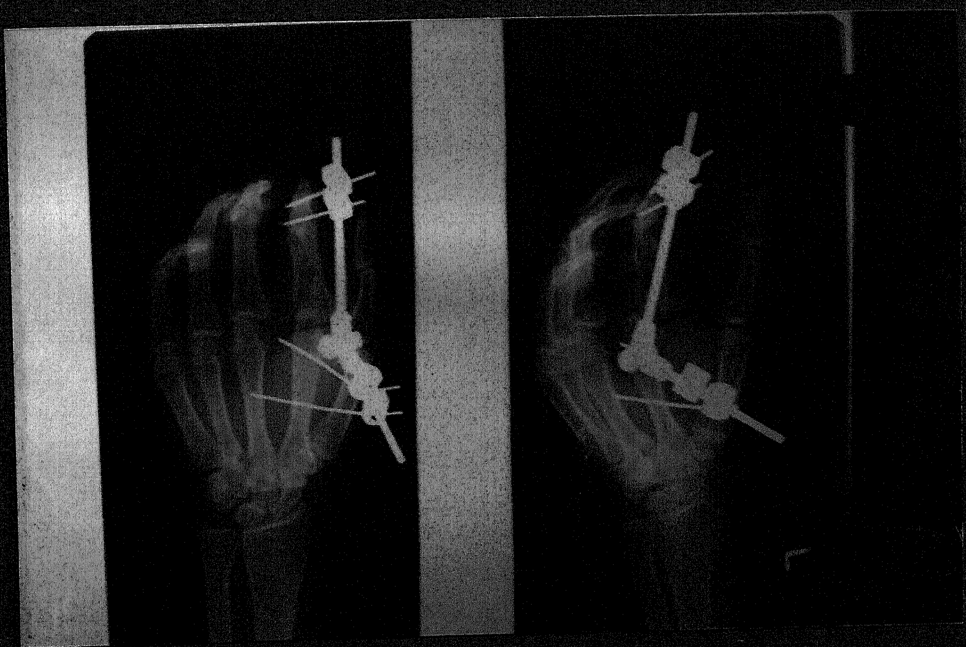
Photograph 19: Showing x-ray of the same patient after fracture reduction, with Joshi's fixator.

Photograph 20 & 21: Showing full movements of the injured hand, with the fixator in position.

Photograph 22: Showing union of fracture in the same patient, with excellent results.

Photograph 23: Showing the same patient had full movements of injured hand.

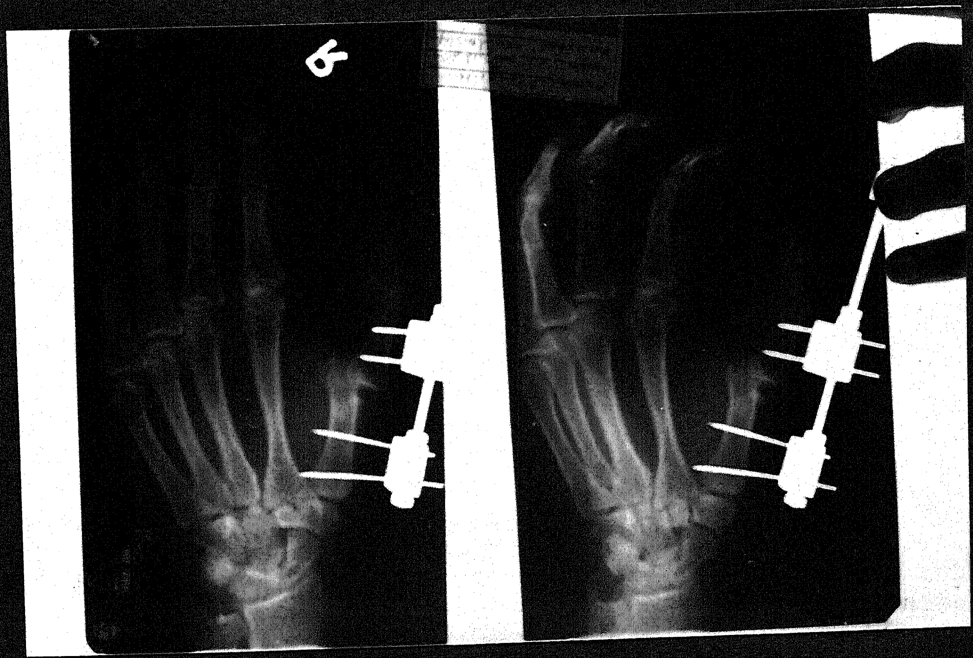
Photograph 24: Showing x-ray of another patient having comminuted fracture of the proximal phalanx of index finger, with involvement of MP joint



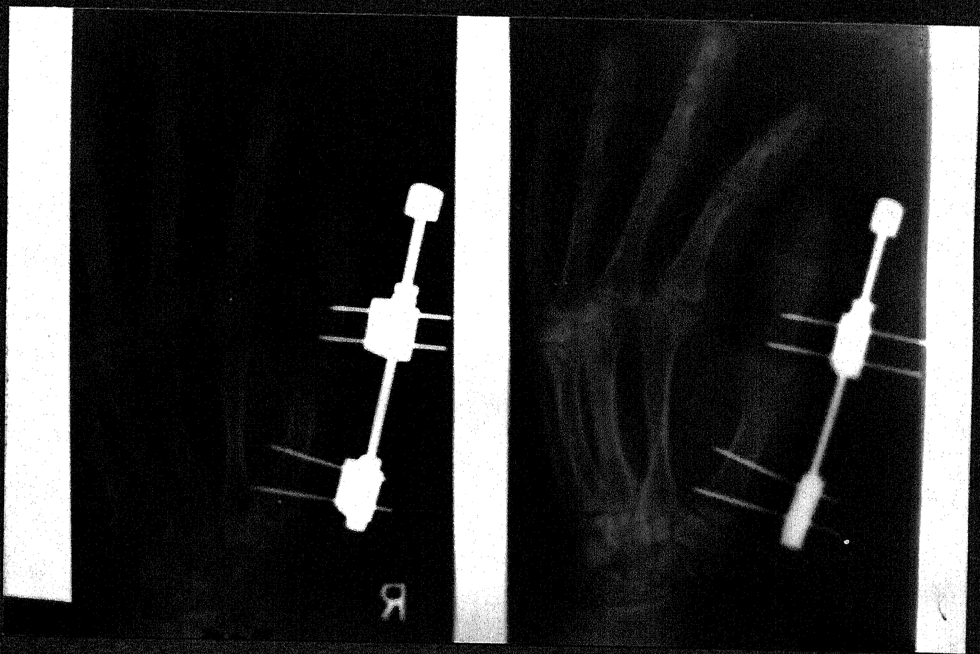
Photograph 25: Showing x-ray of the same patient after application of ray frame.

Photograph 26: Showing full movements of the uninvolved rays.
(This patient had some flexion deformity at the 2^{nd} MP joint, which later on recovered with active physiotherapy, patient categorized in good result)

Photograph 27: Showing x-ray of a patient having neglected dislocation of the first metacarpo-phalengeal joint.



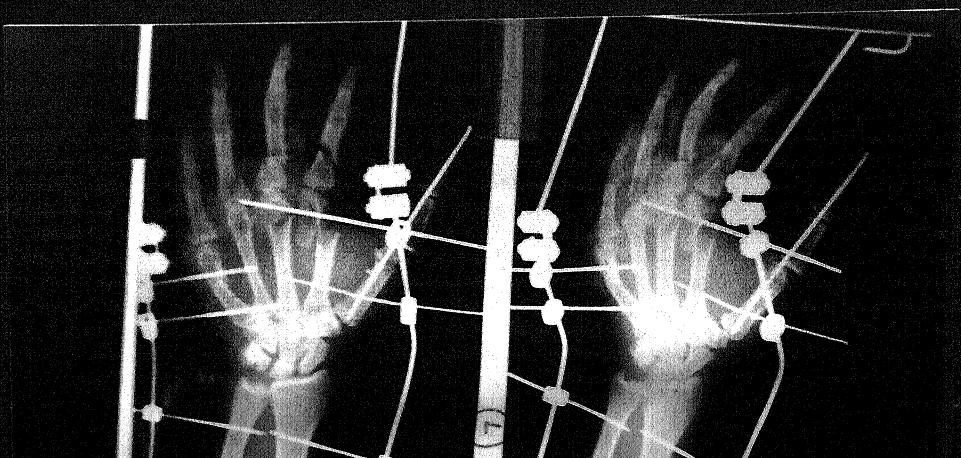
Photograph 28: Showing x-ray of the same patient after application of unilateral double hole distractor.



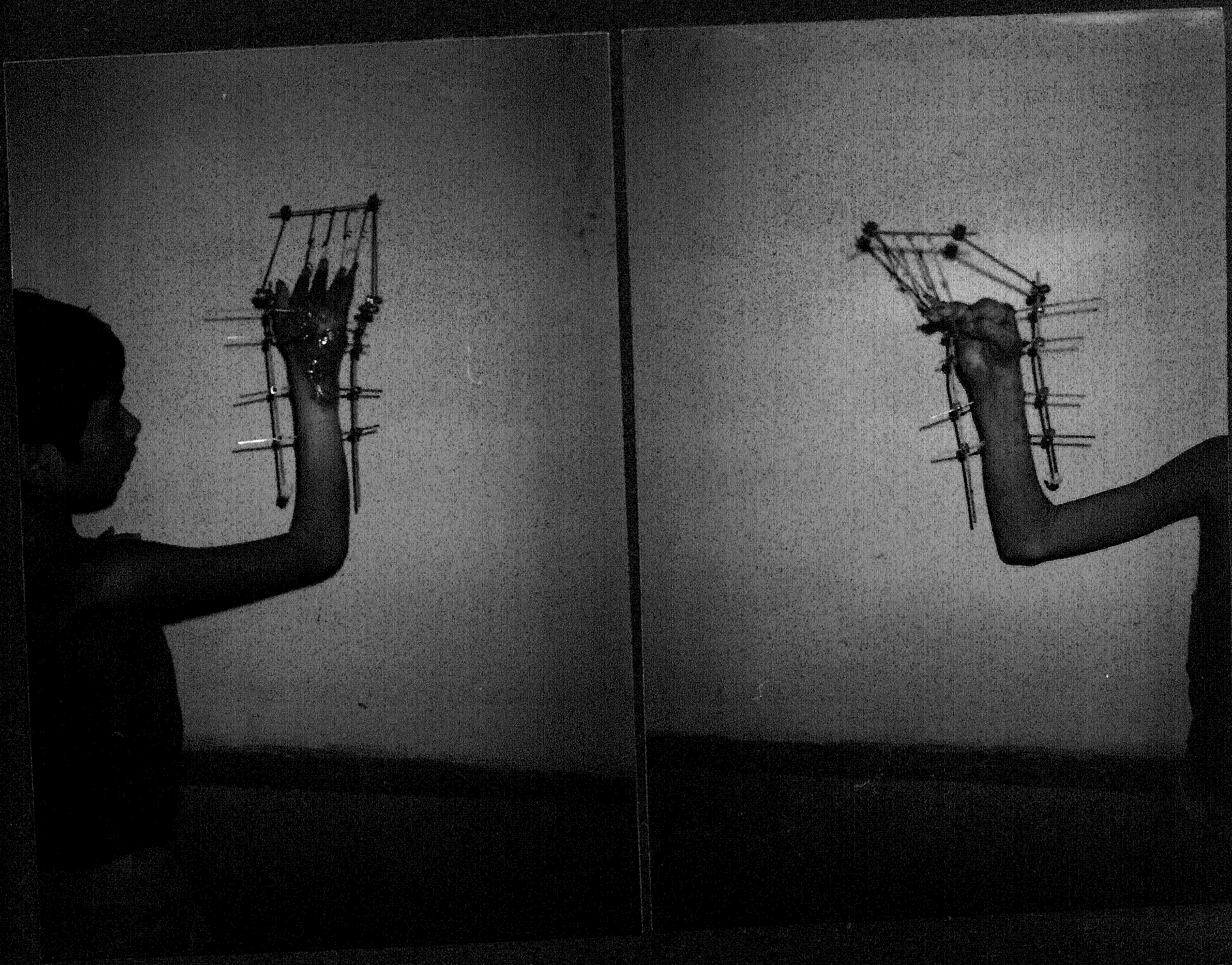
Photograph 29: Showing x-ray of the same patient after final reduction.(distraction started on the third post-op day, at the rate of 0.5mm per day in two settings, with reduction achieved in 28 days, reduction was maintained for 21 days with distractor).

Photograph 30 & 31: Showing good movements of the thumb (abduction and opposition) this patient had mild deficiency of grip strength after removal of fixator, which was improved by active exercises, patient categorized in good results.

Photograph 32: Showing x-ray of a patient having multiple fractures in the hand.

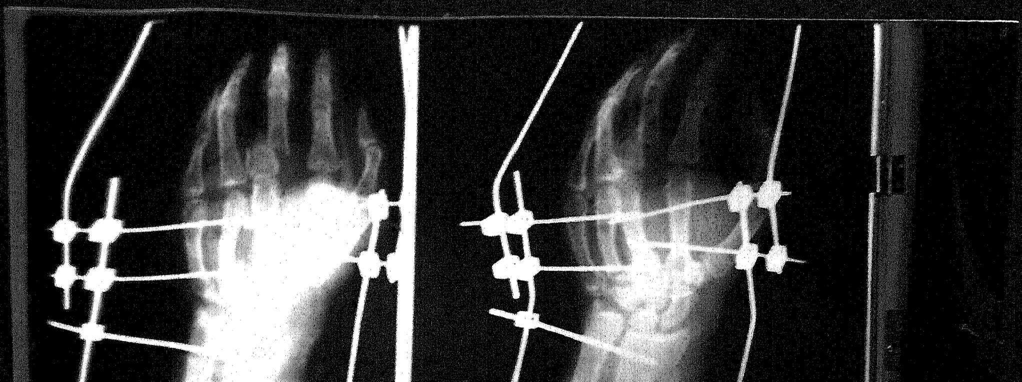


Photograph 33: Showing x-ray of the same patient after application of extended hand frame.

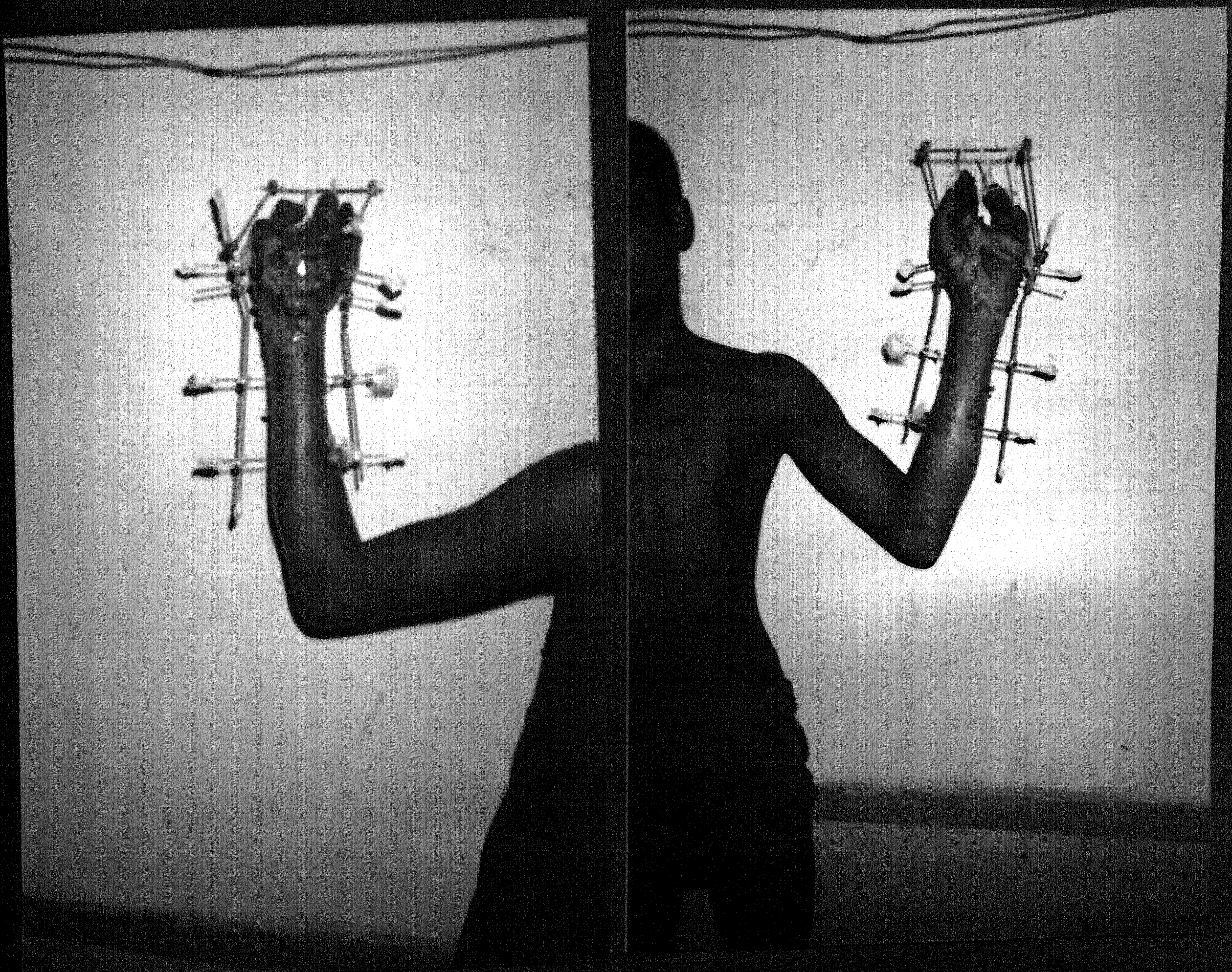


Photograph 34 & 35: Showing the same patient had some movements in rays, with fixator in-situ. (Patient categorized as fair result, because he had moderately deficient grip-strength with deformities).

Photograph 36: Showing x-ray of a patient having fractures of multiple bones of the hand and forearm.



Photograph 37: Showing x-ray of the same patient, after application of the extended hand frame.



Photograph 38 & 39: Showing the same patient had badly crushed, discharging wound with mal-alignment of the fingers.

Photograph 40: Showing x-ray of the same patient , who have developed osteomyelitis later on.(Patient categorized in poor results).

DISCUSSION

DISCUSSION

Although the general principles of trauma management remain the same for all regions of the body, The Hand as a specialized structure inters acting with the environment, is especially sensitive to functional impairment. Fractures of the small tubular bones of the hand occur more frequently than any other region of the skeleton. During *Lorenz Bohler's* 35 years of active clinical practice, he treated approximately 900,000 patients, Of these, 250,000 had finger injuries, including 50,000 open fractures of the phalanges, In spite of the frequency of such injuries, the significance of such fractures of the hands is often under estimated. If meticulous reduction & stable fixation of these fractures is not established with in time followed by proper physiotherapy, the patients may suffer with loss of range of motion in the hand, because of pain & joint stiffness.

The functional out come of the fractures of small bones of the hand is in part dependent, on the severity of the injury & the initial management. The preceding factors cannot be influence by, the treating physician. An accurate assessment of the injury pattern coupled with a working knowledge of appropriate treatment options forms the corner stone of successful initial management. An improper conservative or aggressive debridement of injured soft tissue, regardless of skeletal fixation, may lead to threatening septic

complications resulting in possible loss of fingers or even the hand itself.

The comminuted, contaminated, displaced open fractures combined with soft tissue & segmental bone loss is one of the most severe of all hand injuries. These injuries are a challenge to the surgeon because the stable & accurate fixation of small bones has to be combined with proper drainage, debridement & control of infection, with early mobilization of joints & careful restoration of soft tissue. Rigidly fixing small bones, without too much of periosteal stripping, maintenance of length, keeping adjacent joint free, avoiding too much of metal inside are highly demanding constraints. For the management of these cases, conventional intramedullary K-wires or screws immobilize too loosely, POP immobilization-immobilize extensively & wound could not be inspecting properly, plates are cumber some, increase periosteal stripping & promote infection. These treatment limitation leads to the development of small-scale external fixators designed to reduce & stabilize the small bones of the hand.

In an attempt to develop a less expensive alternative to existing expensive external fixator systems, Dr. B.B. Joshi invented the concept of & developed the JESS. He used this system in more than 150 cases of crush injuries of hand involving soft tissue & bone in varying degrees of severity. Appropriately positioned frames cause minimal interference with gliding structures & adjacent joints,

facilitating early movements & functional rehabilitation, thus minimizing the risk of adhesions & joints stiffness, all on frequent wound inspection & help in healing of soft tissues as well. Current frames are adjustable in three planes, allowing for correction of translation, rotational, & angular deformities. The simplicity of the procedure, the immense versatility & the possibility of readjustment at a subsequent date confer in this system, the unique possibility of achieving good results even in average hands.

Different types of JESS frames were applied in 40 patients of hands & forearm injuries in our study. Out of 40 patients, 36 were males while 4 were females, with the mean age of presentation 32 years (range 11-67 yrs). Sameer et al (1991) conducted a study comprising of 26 patients (21 males & 5 females). Parson et al (1992) also did a prospective study of 30 patients, out of which 26 were male & 4 female, with the mean age of 28 yrs. In the study by Drenth et al (1998) in 33 patients, the mean age was 35 yrs. (range 15-69 yrs) with male predominance (27males & 6 females). Steven et al (1998) did a retrospective study comprising of 86 patients, out of which 75 were males & 11 females with mean age was 32 years (range 14-76 yrs). Von Oosterom et al (2001) in a study of 350 patients, 315 were males & 35 females. With mean age was 35 yrs (range 8-80 yrs).

All these studies concluded that, these are purely the problem of working men.

The modes of injury in our study were mainly thresher/ machine work injuries, Road traffic accident, followed by fall of heavy objects. Out of 40 patients, 21 have injuries involving the right hand while in 19, left hand. Parson et al (1992) found wide variety of mechanism of injury in their study ranging from acute sudden impact (as from punching or crushing) to industrial works. Drenth et al (1998) observed that the most common mode of injury was road traffic accident and injury due to machine and fall of heavy objects. In 30% cases the dominant hand was involved.

These variations in different studies may be due to variable socio-economic condition and occupation of the people of these regions. In this region, inhabitants are poor and occupationally most of them are farmers or laborers and hence they are more prone to injury, particularly hand injuries. Since a few years an increased incidence of road traffic accident had become a major cause of hand injuries, as has been shown in our study, probably due to an increase in the number of vehicle on the road and poor compliance for traffic rules.

The fractures were open in 34 patients while closed in 6 patients, out of 40 patients in our study. The wounds were crushed type in 18 patients. One or more tendons were involved in 6 patients.

Pritsch et al (1981) reviewed 36 metacarpal fractures out of which two were open type. Riggs and Cooney (1983) reported their experience with the Jacquet mini-fixator in 10 hand fractures, 3 of

which were open. Sietz et al (1987) reported on 26 hand fractures in 22 patients, of which 18 were open fractures. Freeland et al (1987) had reported on the use of external fixation in 20 open hand injuries in 12 patients. Ashmead et al (1992) reported 35 cases of hand injuries out of which 12 had open type of fractures. Parsons et al (1992) reported 9 open fractures out of 37 fractures in 30 patients, 6 of them also had tendon injuries. Drenth et al (1998) reported 27 patients, out of 33 having open type injuries, in 12 patients one or more tendon was partially or completely involved, Steven et al (1998) observed 105 fractures in 82 patients out of which 68 fractures were closed and 37 were open.

These above studies indicate towards a gradually increasing incidence of open type injuries, due to high velocity trauma. We observed more than 80% of open hand fractures in our study, out of which 59% were crushed wounds. In our study, 25% patients suffered from thresher injuries. Most of them were alcoholics and under its influences they withdraw protective shields from thresher, during work, thus injuring them during the procedure, due to loss of concentration. Most of these wounds were crushed. Crush wounds were also common in laborers in our study, due to fall of heavy objects (stone, part of machine etc – 25%) over their hands during work. We observed in our study that the incidence of open fractures i.e. crushed and lacerated combined wounds (70%) was much more than closed fractures (30%) due to road traffic accidents. The

incidence of firearm injuries was 15% in our study. In this region, use of firearm is regarded a common custom on auspicious occasions and people, accidentally suffer from these injuries. Apart from this, the incidence of crime is also very high here.

In our study, the pattern of involvement of bones was diverse, isolated both bones forearm fractured in 4 patients, metacarpal in 9 patients, phalanges in 13 patients while combined injuries involved more than two groups of bones in 14 patients. We observed 100 fractures in 40 patients, out of which 50 (50%) were metacarpals, 32(32%) were phalanges and 9(9%) were radius and ulna were fractured, thus phalanges were the most common bones involved in isolated injury while the metacarpals were the most common bone involved in combined injuries. 1st ray was the most commonly fractured (28%) ray involved in our study. 2nd metacarpal was the most commonly fractured (24%) metacarpal while proximal phalanx of thumb was the most common phalanx fractured. Out of 100 fractures, 46 fractures were intra-articular while MP joints (35%) and wrist joint CMC joint (35%) were the most common joints involved.

Smith et al (1987) observed 10 patients with 11 fractures of the proximal phalanx who were treated with the AO/ASIF small external fixator. 7 out of 11 fractures (5 IP joints and 2 MP joints) were intra-articular. Sameer et al (1991) found 7 fractures were intra-articular out of 11 phalangeal fractures and one out of 19 metacarpals fractures. Parson et al (1992) studied 30 patients and concluded that

metacarpals (23) were commonly involved in combined injuries followed by phalangeal fractures (14). Drenth et al (1998) observed 36 fractures in 33 patients, out of 36, 29 phalanges and 7 metacarpals were fractured. The proximal phalanx of ring finger was most commonly involved in his study. Out of 36 fractures, only one fracture was intra-articular. Steven et al (1998) observed 105 fractures in 82 patients out of which 66 (63%) metacarpals and 39(37%) phalanges were fractured. Mullet JH (1999) found 30 intra-articular fractures and 9 extra-articular fractures out of 37 patients, 51% fractures were intra-articular in his study. Distribution of fractures shows that index finger (2^{nd} day) was most commonly involved and most of the fractures involved the proximal phalanx.

These observations are similar to our study. Phalanges are more prone for isolated injuries in our study because of occupation of our patients like reaping, hammering etc. In RTA, fall of heavy objects, fire arm injuries, Blast injuries, flat surface of hands either palmer or dorsal, are usually involved, which is why metacarpals were commonly involved in combined injuries and hence both joint at metacarpals either MP or CMC (wrist joint) joints were commonly involved in our study.

Different types of JESS frames were applied in our study, according to the involvement of bones. Out of 40 patients, different distractors were commonly (27%) applied because 46% of fractures in our study were intra-articular. We applied the principle of

ligamentotaxis to achieve reduction in these cases. We applied extended hand frames and basic hand frames in multiple injuries of hands so that each bone of hand can be fixed, with minimal obstruction of joint movements of uninvolved bones. Ray frames were applied over 2nd ray of 4 patients so that metacarpal and phalanx of involved ray were immobilized with full movements at the other rays. We also applied 1st web space frame in 4 cases so that we could immobilized the thumb in functional position (i.e. abduction and opposition) to prevent formation of adduction contracture and hence maintain grip strength and pinch action of thumb. We also applied Bennett's fracture frame in one case with satisfactory results.

In present study majority of fixators were removed within 6 weeks and in 29 patients (70%) wounds were healed at that time. Fractures were united in 37 (90%) patients at the time of fixator removal.

Bilos et al (1979) observed 15 open phalangeal fractures, out of which 7 intra-articular fractures were united primarily with stable ankylosis and good digital alignment. 6 of the phalangeal shaft fractures were united primarily and one united after a delayed bone graft procedure. No infections occurred in his study. Pritsch et al (1981) reviewed 36 metacarpal fractures treated with K-wire and acrylic cement external fixator. 100% union was observed at 5 wks. No complications arose in this series. Freeland (1987) observed 20 open hand fractures in 12 patients and reported 3 fractures were

managed with bone graft and converted to internal fixations 2-7 days after external fixation and one case required supplementary internal fixation & bone grafting with external fixator frame left in place. 80% fractures united primarily while 20% required delayed bone grafting. Seitz et al (1987) reported 85% union rate at 8 weeks while non-union was present in 4 cases out of 26 hand fractures. Sameer, et al (1991) in a similar study also observed that most of their patients had bony union with in 12 weeks. Parson et al (1992) reported union in all their patients, with metacarpal fractures (mean duration 4.8 weeks) & phalangeal fractures (mean duration 4.5 weeks). Ashmead et al (1992) treated 12 open fractures with external fixation. 10 united primarily while 1 required secondary bone grafting with subsequent bone union while one patient lost to follow up. Drenth et al (1998) removed device at a mean duration of 6 weeks an also observed union in all patients but after a much longer duration of 28 weeks.

The incidence of non-union in our study was 7%, i.e. higher than other studies. There are many reasons for this viz. severity of wounds and wound coverage, neuro-vascular status of injured part, duration since injury, rigidity of fixator and mainly patient compliance. In one case, Haribai, median and ulnar nerve was injured, along with crushing of soft tissue and she had removed POP cast with in 3 weeks, by herself without our advise which resulted in non-union of both-bones forearm, for which bone grafting with DCP fixation was done after treating the infection. Another patient, Gorelal had

infected non-union of both bones forearm for which tricortical iliac bone grafting over square nail after sequestrectomy was done. In one case Malkhan, who had bone fragment loss of 1st metacarpal due to fire arm injury, cancellous bone grafting was done after subsidence of infection. We did not perform primary bone grafting in any case. Primary internal fixations with intramedullary K-wire were required in 3 cases while in 2 case internal fixation with intramedullary K-wire was required with in 7 days along with external fixation. In these cases comminution was so severe that external fixation alone could not stabilize fractures. Delayed union was observed in 2 cases, because of loosening of K-wires for which POP cast immobilization was done after removal of external fixator.

Most common complication observed in present study were deformity of injured part (45%) followed by swelling in 25% of cases. Freeland et al 1987 observed 20 open hand fractures in 12 patients and described two complications- Mild deformity (10%) and ankylosis (55%). Sietz et al (1987) reported pin tract infections in 1 case and malunion in 1 case out of 22 patients. Green et al (1990) observed that the incidence of pin site infection was 8.4%, the incidence of ring sequestra at the pin site and osteomylitis was approximately 0.2%. Sameer et al (1991) in their series of 26 patients treated with external fixator did not encounter any deformity, pin site infection, loss of reduction. There was no significant joint stiffness, except in 2 patients who refused to have physiotherapy and neglected

their exercise. Cziffer (1993) observed a few minor wound problems and superficial pin tract infection in 4%, no deep infection occurred in this study. Drenth et al (1998) found complications in 10 fractures in the form of loosening of pin (in 6 patients), restriction of movements of adjacent fingers due to mechanical interference by the device (3 patients) and loss of reduction (1 patient).

We observed deformities in 18 cases, out of which 12 had mild deformities (mostly flexion deformity of MP joint). Active exercises with the gripper was advised, for improving the strength of small intrinsic muscles, along with other conservative measures and muscle training activities with satisfactory results in all case. Corrective osteotomy was done in 1 case and Z-plasty in 1 patient, with satisfactory results after active exercises. In one case, Haribai, deformities were corrected at the time of internal fixation with DCP. While in one case, Rambihari deformities were corrected with the removal of sequestreted 3rd metacarpal for which fibular bone grafting with internal fixation with K-wire was done later on for bone gap. In one case, Gorelal deformities were corrected with sequestrectomy and in One patient,Rajpal, Darrach's procedure was done for cosmetic improvements. Incidence of deformities is very high in our study as compared to others, because of multiple factors e.g. non-compliance and illiteracy of our patients, lack of proper infrastructural facilities like c-arm etc.

Swelling was present in 10 cases, because of osteomyelitis and pin tract infections, which subsided after treatment of these complications. 10 patients were complained of pain, because of these infections. Superficial pin tract infections were present in 4 patients (10%), which were treated with antibiotics as per culture sensitivity reports. Osteomylitis was present in 6 patients (15%), out of which 4 were treated with simple sequestrectomy while in 2 cases sequestrectomy was done with bone grafting and internal fixation. The incidence of infection is high in our study because of poor socio-economic conditions and illiteracy of our patients. They did not care for their wounds by themselves and took imbalanced, low protein and poor vitamin rich diet, thus rendering them more prone to infections.

The incidence of skin necrosis was 20% because of high percentage of crushed wounds in our study. In 5 patients, K-wires became loose because of pin tract infections. In one patient, Balveer, little finger becomes gangrenous, because of ulnar artery injury and loss of fifth metacarpal, due to firearm injury, which later on got disarticulated through MP joint.

At the final follow up 51% of MP joints, 68% of IP joints, 70% of PIP joints, 74% of DIP joints and 58% of wrist joints regained their normal movements. Freeland et al (1987) observed loss of motion with all intra-articular fractures particularly those involving PIP joints. He recommends stabilizing these complex intra-articular fractures in a position of function, in anticipation of fibrous or

complete ankylosis. Sameer et al (1991) observed in 19 metacarpal fractures the percentage return of normal active range of movements varied from 77-100% with a mean return of 96%. In phalangeal fractures, the percentage return of total normal active range of movements varied from 66-98% (mean 84%). In the 7 patients with intra-articular fractures the return of total normal active range of movements varied from 66-100% (mean 87%).

Parsons et al (1992) observed good phalangeal functions in 94% of metacarpal and 85% of phalangeal fractures by 9 weeks. Drenth et al (1998) evaluated results based on range of movements, along with residual pain and reported excellent results in 15 cases (41.7%), good in 10 cases (27.8%), fair in 3 (8.3%) and poor in 8 (22.2%). They concluded that functional results after metacarpal fractures were better than those after phalangeal fractures and fractures of middle phalanx had better recovery than those of proximal phalanx. 28 of 33 patients were satisfied with their results (15 had excellent, 10 had good results).

In the present study of 40 patients, grip strength was normal in 20 cases, mildly deficient in 12 cases, moderately deficient in 6 cases and severely deficient in 2 cases.

The results in our study were graded as excellent in 29 cases (72.5%), Good in 8 cases (20%), fair in 1 (2.5%) and poor in 2 (5%). 36 of 40 patients were satisfied with their results.

Patients with the foot injuries and deformities attending Department of Orthopaedics, MLB Medical College, Jhansi, during this interval did not qualify the essential criteria for selection of patients so that we could not observe the role of JESS in these problem.

CONCLUSION

CONCLUSION

The present study "was conducted in Department of Orthopaedics, MLB Medical College, Jhansi. 40 patients with hand & forearm injuries were subjected in this study. Patients were assessed thoroughly before & after application of JESS fixator. All the necessary procedures were done before & after removal of JESS fixator so that functions of the hand can be maintained normal either physiologically or cosmetically active & passive exercises were started soon, as per pain tolerance & compliance of patients along with other rehabilitation procedures before & after removal of fixator. We compare the observations of our study with other studies and on the basis of these, we concluded our study as.

A - DISADVANTAGES IN CONSERVATIVE TREATMENT:

-Immobilization of adjacent joints

-Immobilization of dynamic structures

-Secondary displacement is not uncommon

-The control of small bone fragments by a cast is in efficient & difficult.

B - DISADVANTAGES IN ORIF (OPEN REDUCTION & INTERNAL FIXATION)

1- Access to the bone can be difficult; because of the complex soft tissue structures the marginal error is small.

2- Plating strips the periosteum, impairing the vascular supply to the bone fragments smaller fragments close to the joint are difficult to control with a plate.

3- K-wire fixation although widely used to maintain fragment positions effectively. The additional use of a splint is after necessary.

4- K-wires may migrate into the adjacent joint or back out.

5- The use of internal fixation may results in surgical intervention on two occasions, as the implant may need to be removed.

ADVANTAGE OF JESS

1. With the use of thin & smooth wires placed away from the site of injury in a stable configuration created by an exoskeleton of connecting system & link joints, it provides a stable skeletal environment aiding rapid healing of soft tissues.
2. The system is simple & modular; it assists the surgeon in obtaining tissue stabilization, spontaneous revascularization & tissue expansion by gradual & controlled distraction.
3. Limiting the frame configuration to the involved bone alone allows immediate mobilization of the adjacent joint thus restoring circulation & prevents lymph's or venous stasis leading to lesser incidence of infections.
4. Ability to add dynamic component into the frame & permit concurrent mobility of the joints of the injured hand since mobilization keeps the gliding structures moving, functional restoration is expedient.

5. Precise positioning of the hand allows tissue transfer, tissue transplants or other reconstructions with simultaneous correction of realignment & joint mobilization.
6. Joint space & alignment of articular surfaces are maintained by ligamentotaxis in intra articular fracture.
7. In case of bone loss better maintenance of length was achieved, the patients hand can be immobilized in functional position, so chances of stiffeness in non functional position is much less as compared to immobilization in POP slab.
8. It allows repeated wound inspection, cleaning & dressing without change of position, during the healing stages.
9. It allows aeration under the dressing & thus prevents sweating & maceration of tissues which may cause secondary infection of the graft area.
10. Transarticular wire fixation can cause infective arthritis. K-wires in JESS are extra-articular, thus avoid this complication.
11. It is light & patient friendly, in comparison to the fixation carried out by plaster cast, or splints.

DISADVANTAGES

1. Pin site drainage, pin tract infection, pin loosening, ring sequestrum at the pin site with osteomyelitis because of open injuries.
2. Neurovascular & musculotendinous injury
3. Malunion & Non union, if fixator not assembled properly

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